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ASTM BULLETIN

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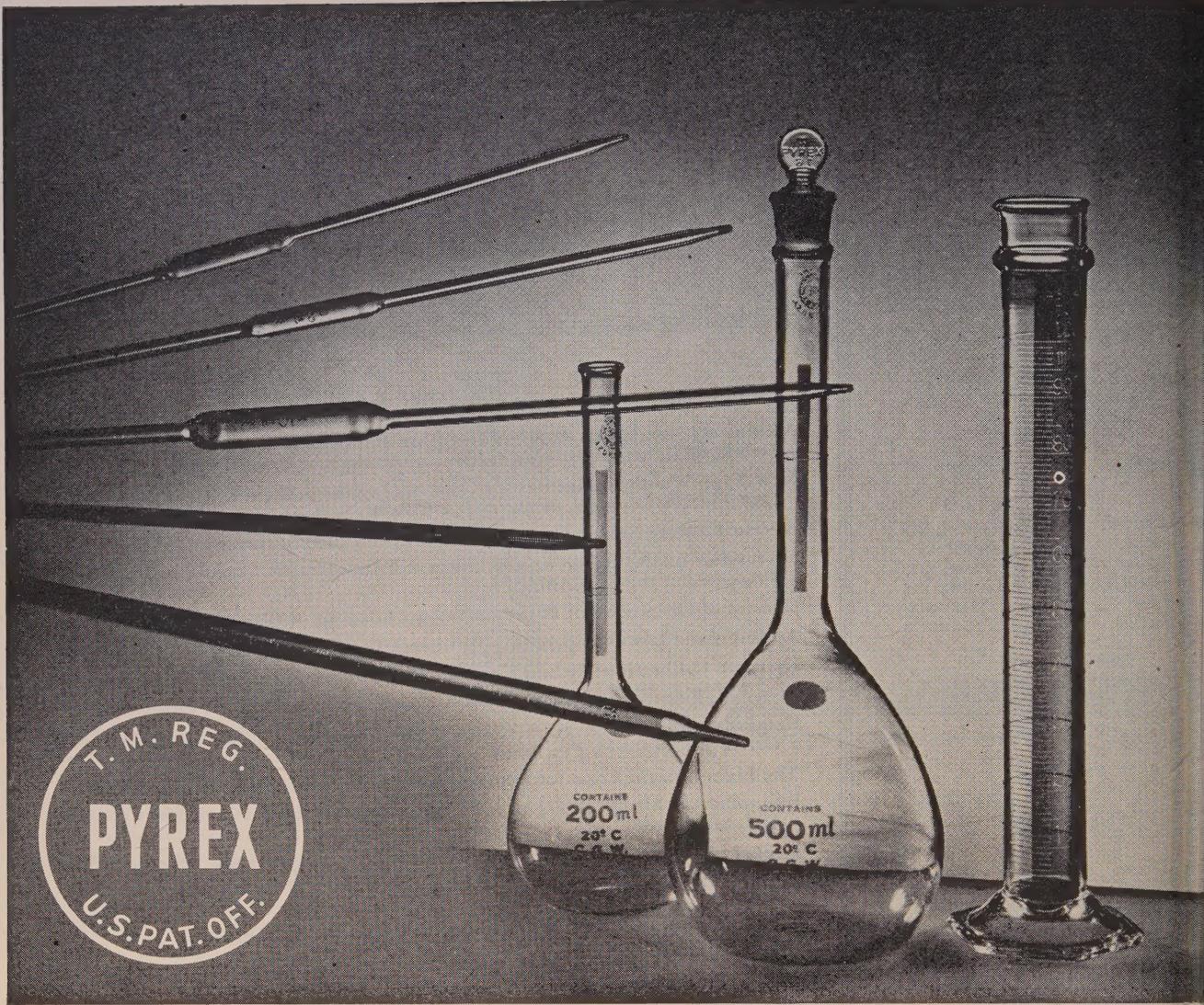
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OCTOBER—1948

No. 154



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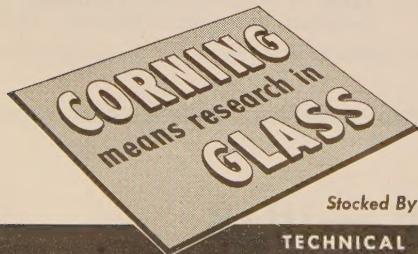
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ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

TELEPHONE—Rittenhouse 6-5315

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October 1948

Several New Specifications and Tests Accepted

Standards Committee Approves Actions on White Metals, Aluminum-Base Castings, Petroleum Products, Shipping Containers, Metal Analysis, Particle Size, Trolley Wire, and Truss Assemblies

SEVERAL new tentative specifications and test methods were approved by the Administrative Committee on Standards on September 29 in the Committee convened at A.T.M. Headquarters in Philadelphia. In addition to new tentatives the committee also approved numerous revisions in existing tentatives, which changes will be published this Fall, and also approved for publication as tentative proposed revisions in certain standard specifications and tests. These later revisions, of course, do not become a part of the standard until adoption by the Society next year or later.

The accompanying table lists the actions, together with the latest designations. It will be noted a wide range of materials and subjects are involved. All of the new and revised specifications and test methods will be published in the 1948 Supplements to the 1946 Book of Standards, and they will be issued in separate pamphlet form as soon as possible. Some will be available before the respective Supplement books issued in December and January, a perhaps not until the Supplements have been published.

Society Acts on Standards Throughout

Presumably all A.S.T.M. members and those concerned with its work know that the Society continually is acting on recommendations of the various technical committees to approve new specifications and tests, and to act on revisions. The Administrative Committee on Standards has the responsibility of determining whether a consensus has been reached in the technical committee and whether the various committees and regulations have been com-

plied with in the development and approval of the proposals in the technical groups. Usually the Administrative Committee has a full-day meeting in the

Fall and may meet at other intervals throughout the year, and it also acts by letter on the various recommendations which are submitted to it throughout the

Actions by the A.S.T.M. Administrative Committee on Standards, September, 1948

New Tentatives

Specifications for:

Copper and Copper Alloy Metal-Arc Welding Electrodes (B 225—48 T). Preformed Expansion Joint Filler for Concrete (Bituminous Type) (D 994—48 T).

Bituminous Paving Plant Requirements (D 995—48 T).

Methods of:

Drop Test for Cylindrical Shipping Containers (D 997—48 T).

Vibration Test for Shipping Containers (D 999—48 T).

Testing Truss Assemblies (E 73—48 T).

Definitions of Terms:

Shipping Containers (D 996—48 T).¹

Tentative Revisions of Standards

Specifications for:

Bronze Trolley Wire (B 9—46).

Copper Trolley Wire (B 47—46).

Figure-9 Deep-Section Grooved and Figure-8 Copper Trolley Wire for Industrial Haulage (B 116—46).

Revision of Standard and Reversion to Tentative

Methods of:

Test for Saponification Number of Petroleum Products by Color-Indicator Titration (D 94—45).

Revision of Tentatives

Specifications for:

Corrosion-Resisting Chromium and Chromium-Nickel Steel Welding Electrodes (A 298—48 T).¹

White Metal Bearing Alloys (B 23—46 T).

Aluminum-Base Alloy Sand Castings (B 26—47 T).

Soft Solder Metal (B 32—46 T).
Aluminum-Base Alloy Permanent Mold Castings (B 108—47 T).
Aluminum-Base Alloys in Ingot Form for Sand Castings, Die Castings, and Permanent Mold Castings (B 179—47 T).
Air-Entraining Portland Cement (C 175—47 T).
Gasoline (D 439—40 T).
Diesel Fuel Oils (D 975—48 T).
Thermometers (E 1—47 T).
Apparatus for Chemical Analysis of Metals (E 50—48 T).

Methods of Test for:

Knock Characteristics of Aviation Fuels by the Aviation Method (D 614—47 T).

Ignition Quality of Diesel Fuels by the Cetane Method (D 613—47 T).

Sulfur in Lubricating Oils Containing Additives and in Additive Concentrates by Bomb Method (D 894—46 T).

Knock Characteristics of Motor Fuels by the Research Method (D 908—47 T).

Knock Characteristics of Aviation Fuels by the Supercharge Method (D 909—47 T).

Interfacial Tension of Oil Against Water by the Ring Method (D 971—48 T).

Particle Size Distribution of Subsieve Size Particulate Substances (E 20—33 T).

Definitions of:

Terms Relating to Adhesives (D 907—48 T).¹

Procedures Relating to Conditioning and Weathering (E 41—42 T).

Withdrawal of Tentative

Specifications for:
Sampling Petroleum and Petroleum Products (D 270—33).

¹ Approved on August 3, 1948.

year. Thus if a technical committee has a most urgent matter on which it has reached conclusions, the Society's procedure permits prompt action through the Standards Administrative Committee. This group gives a searching analysis to each of the proposals and is particularly alert to explanations of negative votes.

Actions by the Standards Committee are listed in the various issues of the ASTM BULLETIN, and where feasible, notes on the actions are published. In the material which follows an attempt is made to convey to members some idea of the subjects involved in the specifications and tests. The committee rejected certain recommendations from the technical committees and these, of course, will be referred back to the respective groups.

Solder Metal and Bearing Alloys:

The actions involving the Specifications for Soft Solder Metal (B 32) and Bearing Alloys (B 23) emanated from Committee B-2 on Non-Ferrous Metals and Alloys. Two additional alloys have been added to the group of solder metals, designated 5A and 2A, respectively, with the desired tin at 5 and 2 per cent, respectively, maximum antimony at 0.12, and nominal lead for 5A set at 95 per cent, and for 2A at 98 per cent. With these two new new grades there will be 30 grades covered in the specification, with tin-lead, tin-lead-antimony, and silver-lead alloys.

The White Metal Bearing Alloy Specification (B 23) will incorporate as a result of the latest action revised chemical compositions for Alloy No. 3. The minimum, desired, and maximum requirements, per cent, are, respectively, as follows: for antimony 7.5, 8.0, and 8.5; for copper 7.5, 8.0, and 8.5; and for tin 83.0, 84.0, and 85.0.

Alloy No. 15 is to have the copper requirement of 0.40 per cent minimum deleted, and by agreement a narrower range of antimony can be specified. Full requirements of this specification are given in the 1946 Book of A.S.T.M. Standards, p. 615.

Aluminum-Base Alloys for Castings:

A statement from A.S.T.M. Committee B-7 on Light Metals and Alloys indicates that the principal revision in the Aluminum-Base Sand Castings Specification (B 26) concerns alloy SC8, which now includes two slightly different commercial alloys. The revision separates the two by establishing alloy SC9 and adjusting the requirements applicable to alloy SC8. Revisions in alloys CS5 and SC42 are based on the conclusion, from unpublished data, that increasing the permissible zinc content

is not undesirable from a use viewpoint and is desirable economically.

In the Permanent Mold Specification (B 108) the principal changes are the division of the present alloy SC8 into alloys SC8 and SC9 and the addition of a Table III, giving typical yield strengths. The division of alloy SC8 recognizes that it now covers two commercial alloys with slightly different characteristics. The minor revision of alloy SC1 recognizes that its characteristics are not changed by increasing the manganese and zinc and that economics indicate the changes to be desirable.

The changes in the Ingot Specification (B 179) are a consequence of the changes in B 26 and B 108, since this specification covers the material to be used in making the product castings.

Proposed Changes in Trolley Wire Specifications:

The revisions to be published as tentative in the standard specifications for certain types of trolley wire, as noted in the table, are intended to recognize current practice and to eliminate unnecessary and often impossible attempts to gage the many dimensions that have been shown on drawings of the sections. The revision also eventually will recognize the determination of unit weight by determining the weight of a sample length.

Specifications for Filler Metal:

In addition to specifications for Mild Steel Arc Welding Electrodes (revised A 233) and Low Alloy Steel Arc Welding Electrodes (A 316), the Joint Committee on Filler Metal has completed important revisions of the former tentative specifications for Corrosion Resisting Electrodes (A 298), and has completed a new tentative for Copper and Copper Alloy Electrodes (B 225). This latter is the first in a series to cover copper and copper alloy materials. Following the standard pattern of requirements and arrangement it includes classifications for copper, phosphor-bronze, copper-nickel, copper-silicon, and aluminum-bronze materials. Arc welding of these copper alloys has increased considerably, and these new specifications are expected to meet the need for suitable classification of the filler metal used. Like each of the other filler metal specifications, there is included a guide to the classification of electrodes, which is intended to supplement the requirements and provide the user with helpful information to assist him in selecting materials best suited to his needs.

The revised corrosion-resisting electrode specification has been expanded so that there are now covered some forty classifications.

The Joint Committee responsible for the work on filler metals functions under

the auspices of the American Welding Society and A.S.T.M.

Copies of all of the filler metal specifications are now available in separate pamphlet form at 25 cents each.

Air-Entraining Portland Cement:

With the addition in June by action at the A.S.T.M. Annual Meeting of new Type IIIa Cement (Specification C 175) which new type covers a high early-strength air-entraining product some editing of the "Scope" paragraph is necessary and the latest action approves this new scope to read as follows:

"Scope.—These specifications cover three types of air-entraining portland cement for use where air-entrainment is desired as follows: Type Ia—for use in general concrete construction when the specific properties specified for Types IIa and III are not required; Type IIa—for use in general concrete construction exposed to moderate sulfate action, or where moderate heat of hydration is required; Type IIIa—for use when high-early-strength is required."

This scope was approved at the June meeting of Committee C-1 on Cement and subsequently by letter ballot.

Petroleum Products and Lubricants Gasoline, Diesel Fuel Oils, Knock Characteristics:

The Standards Committee acted upon recommendations from Committee D-2 on Petroleum Products and Lubricants, the specifications and tests being noted in the accompanying table. One matter approved was to rectify an omission in the Gasoline Specifications (439), lowering the A.S.T.M. gum content of motor gasoline from 7 to 5 ml per 100 ml.

In the very extensive 1948 annual report of Committee D-2 there had been published a Proposed Test for Interfacial Tension of Oil Against Water, and some desirable changes were noted. This latest action corrects and amplifies this 1948 proposal with the designation D 97-48 T.

The revision of the important Diesel Fuel Oil Specifications (D 975) will be of widespread interest since it covers "Statement on Significance of A.S.T.M. Diesel Fuel Specifications" and will appear as a supplement to these specifications which were approved at the June meeting. The introductory paragraphs in the statement on the significance are as follows:

"The properties of commercial fuel depend on the refining practices employed and the nature of the crude oil from which they were produced. Distillate fuel, for example, may be produced within a boiling range of 300 F. and 750 F. having many possible combinations of various properties such as volatility, ignitability,

city, viscosity, and other characteristics. The A.S.T.M. (D 975-48 T) Tentative Specifications for Diesel Fuel Oils are intended as a statement of permissible limits of significant fuel properties used for classifying the wide variety of commercially available diesel fuel oils. Limit values of significant properties are provided for three general classifications of diesel fuel oils...."

Changes in Research Method for Knock Characteristics (D 908) Result from Increasing Cooperative Test Program.—Important changes in the Tentative Test Methods for Knock Characteristics of Motor Fuels by the Research Method (D 908) have been issued as a result of a very interesting research carried on in Committee D-2's Division on Combustion Characteristics, and in one sense are a good example of the significant way in which A.S.T.M. technical committees frequently must carry out rather detailed and exhaustive research investigations before there are sufficient data upon which to base important recommendations in a standard. In the present instance a detonation meter is recommended as optional equipment in place of the bouncing pin, and there is also a revised section on reproducibility which discusses the number of tests required for the accuracy desired. There was submitted to the A.S.T.M. Standards Committee, to justify incorporation of the detonation meter, a report on the extensive research conducted. All told, there were 858 comparative ratings established from tests on the older method and 483 based on the research method, with the definite conclusions resulting that the detonation meter does not change the rating significantly. With performance characteristics of the meter comparable with those of the bouncing pin, the meter is very advantageous since its sensitivity can be readily adjusted. Based on altitude tests, both the meter and pin respond similarly to changes in barometric pressure, and operator reaction to the meter has been extremely favorable. Fifteen organizations participated in the extensive research investigations.

In the Revised Test for Ignition Quality of Diesel Fuel (D 613), for Knock Characteristics of Aviation Fuels by Aviation Method (D 614) and by Supercharge Method (D 909), revised sections on reproducibility will be incorporated.

The Revision and Reversion to Tentative of the former standard Test for Saponification Number (D 94) involves a table of values to use for fatty oils and fats and includes a "definite" value as well as the range. The test requires the use of the "definite" where the correct value is not known rather than per-

mitting selection from the range shown.

The withdrawal of the Standard Methods of Sampling Petroleum and Petroleum Products (D 270) is based on the fact that it is obsolete, and further that there is in process a revised method which it is hoped can be submitted for publication early in the Spring of 1949.

Bituminous Road Materials:

The new Tentative Specifications covering Bituminous Paving Plant Requirements (D 995) have been established by Committee D-4 because these requirements were contained in each of two specifications—Hot-Mixed, Hot-Laid Asphaltic Concrete Base and Surface Courses (D 947), and Asphaltic Mixtures for Sheet Asphalt Pavements (D 978). The new tentative will avoid duplicating the requirements from the materials specifications. This tentative is an example of an instance where a committee responsible for important specifications and tests feels it essential that to have the requisite quality and performance desired there must be set forth requirements on equipment. There are many instances where a technical group must go beyond the strict field of specifications and test requirements, and the Society's procedure is sufficiently flexible to permit such action.

At the present time there is only one specification covering Preformed Expansion Joint Filler for Concrete (D 544). The existing specification does not include a filler of the bituminous type. It was deemed advisable to propose a separate new specification for a bituminous type joint filler because of the differences in composition which have necessitated setting up different requirements (except as to compression requirements) than those in the existing specification. The designation D 994 has been assigned.

Shipping Containers—Tests and Definitions:

Continuing activity on the part of Committee D-10 on Shipping Containers is indicated by the two new tests which were approved, one covering a drop test for cylindrical containers, the other a vibration test. The test for cylindrical products is justified because the present over-all drop test (D 775) is not applicable. The new method covers the procedure for drop testing substantially cylindrical shaped bulk shipping containers such as barrels, drums, kegs, or pails (metal, fiber, or wood) to measure their ability to withstand rough handling.

The Vibration Test for Shipping Containers (D 999) covers a procedure to determine the ability of a container with

its interior packing and means of closure, to provide sufficient protection to its contents when subjected to the vibrations of transportation so that the contents will not be damaged by these vibrations. The test is recommended to determine an economical design of container, proper interior packing and adequate strength of closure. This procedure is suitable for testing containers of any form, any material, any kind and design of interior packing and means of closure and any size and weight.

Terms for Shipping Containers.—Committee D-10 has been working for many months on proposed definitions for a large number of terms pertaining to shipping containers and related items. The standardizing of definitions is one of the important responsibilities of A.S.T.M. technical committees. The definitions are important in order to establish correct nomenclature for scientific and technical problems, and they also are frequently of utmost importance in connection with commercial and legal matters.

The new definitions, carrying a designation D 996, cover more than 100 terms such as: bag, barrel, basket, can, carton. Various types of containers such as: glass, wood framed, etc.; common type hamper, and various types of nails, stripping, wadding, and the like are covered. Some of the definitions are relatively concise—"box," for example, is described as "A rigid container having closed faces." A description of a hamper is somewhat more lengthy reading "A container (commonly used for shipping fruits and vegetables) circular, elliptical or polygonal in horizontal cross section, the top dimensions being usually greater than the bottom. It has slatted sides and a bottom which may be loose, stapled or nailed in place. The top may or may not be open."

Particle Size Distribution:

The Revised Test for Particle Size Distribution (E 20) in the form of a new Recommended Practice using microscopic procedures, is based on intensive review and studies conducted by a special section in Committee E-1. The method was first issued in 1933, and a series of round-robin tests were made prior to the war, and have been continued in the past several years, to improve and perfect the requirements. The committee responsible does not consider the revised method as a finished product and will continue to study it from time to time. Actually the extensive research carried out, while satisfying the committee on the errors of measurement, still has not shown reasons for certain of the effects, and some of the committee men are continuing their studies of these

interesting phenomena. The requirements are broad because of the wide range of products which can be measured with the microscope.

Thermometers and Weathering:

Seven new thermometers are covered in the revision of the Tentative Specifications for Thermometers (E 1). The three tank thermometers were requested by Committee D-2 on Petroleum Products and Lubricants. Also the low range tag closed tester thermometers were prepared for use in a D-2 method. The bomb calorimeter thermometers are needed for use in calorimetric determinations. Thermometer 52 F. is being withdrawn since manufacturers of the apparatus use different types of these thermometers. Detailed requirements for this particular thermometer are being included in Methods D 900 by Committee D-3.

The revision in the Tentative Requirements Relating to Conditioning and Weathering (E 41) involves a change in the temperature of the standard laboratory atmosphere from the present 25 C. (77 F.) to 23 C. (73.4 F.). This change was approved so that there

would be a single set of conditions. Various temperature ranges have been in use.

Apparatus for Chemical Analysis of Metals:

A.S.T.M. Committee E-3 on Chemical Analysis of Metals has developed an important document entitled "Recommended Practices for Apparatus and Reagents for Chemical Analysis of Metals" (E 50). Here detailed descriptions of recommended equipment and for preparing standard solutions, etc., are included, and the data are considered very helpful by the large number of chemists and analysts who use the A.S.T.M. methods. The committee has developed more complete and up-to-date information covering the apparatus for the potentiometric titrations and for the mercury cathode cell, and will also add to the method a new description for apparatus for titration to a dead-stop end point, which procedure is coming into more widespread use.

Testing Truss Assemblies:

The new Tentative Method for Testing Truss Assemblies (E 73) was de-

veloped in Committee E-6 on Method of Testing Building Constructions. The purpose of Committee E-6 is to formulate methods of test for building components and this proposed test procedure provides a method of evaluating building truss assemblies under actual or simulated service conditions to determine adequacy of materials and design. Since it is believed that there is a real need for such a procedure, it is recommended that it be issued as a tentative to give it wider distribution and therefore the benefit of increased use and determination of its adequacy.

The methods cover general provisions that is, the application of loads, measurements required, etc., and then discuss testing of trusses in various positions—normal, inverted, horizontal, trusses in a structure, etc.

Adhesives Nomenclature:

The revised definitions of terms relating to adhesives include descriptions of a number of terms not included in the first published version of this A.S.T.M. document. Some of the new terms cover bag molding, blister, joint conditioning time, tack, etc.

Important Announcement on Future Policies on Publication Technical Papers, Committee Reports, Standards

For several years it has been felt that the publication structure of the Society should be reexamined and studied in the light of recent developments, particularly the increase in technical papers and the steady growth of standards. For one thing the use of the BULLETIN for technical papers, begun on a major scale about ten years ago, led to suggestions that possibly the BULLETIN should be expanded into a monthly technical journal, in which all technical papers (including those presented at the annual meeting) and committee reports should be published, eliminating the bound volume of *Proceedings* except as members might order a yearly binding of the sections of the journal devoted to papers and reports. An alternate suggestion was to publish the technical papers in a monthly or quarterly book of *Proceedings*, retaining the BULLETIN essentially as a news medium. One of the principal ideas back of these suggestions was that of "current" rather than "annual" publication of A.S.T.M. papers.

As to publication of standards, the increasing volume of standards and the utility and popularity of the separate

compilations of standards led to various suggestions, among them the use of the compilations in place of the Book of Standards as the main avenue of publication. The use of loose-leaf or loose-unit methods of publishing was also proposed. At the request of the Board, the Administrative Committee on Papers and Publications, over a two-year period, has made a very thoroughgoing study of the entire publication setup. As outlined in the Annual Report of the Board of Directors, two special study committees were set up, one to explore the most desirable manner of publishing technical papers, the other to look into the implications of the ever-increasing volume of standards and to determine the feasibility of various schemes of publication.

Based upon these very extensive studies, the Publication Committee submitted to the Board a number of recommendations. These recommendations, to which the Board subscribes, are briefly summarized as follows:

As to Technical Papers:

No major change will be made. Preprinting of papers during the year, and

before and after the annual meeting, bring technical data to the members rapidly as possible. The bound volume of *Proceedings* will be continued to provide a permanent record, the need and value of which are clearly established by these studies. Although a proposal to publish a monthly technical journal is not favored, the BULLETIN will be expanded from six to eight issues annually, to provide increased facilities for timely publication of papers of current and general interest and opportunity for more frequent contact with members and other readers of that publication. The staff has been directed to proceed with plans for this important expansion.

The important place that the Technical Publication Series has assumed is recognized. There is an ever-increasing number of symposiums and paper in specialized fields that are issued as special publications, and it is proposed to continue and extend this practice.

As to Committee Reports:

These will be handled substantial heretofore, with, however, increased use of the BULLETIN for progress reports.

(Continued on page 11)

1949 Book of Standards to be in Six Parts

Slightly Revised Members Charges to be in Effect

AS ANNOUNCED in the Annual Report of the Board of Directors and covered in an article in issue (see page 8) on publication dates, it is necessary to publish the edition of the Book of A.S.T.M. standards in six parts instead of five—chiefly because of the unmanageable size which Part II on Nonmetallic Materials—Constructional will have grown. Because of the considerably higher cost (about 45 per cent) of the 1949 Book as compared with the 1946 Book of Standards, brought about both by greater size and higher printing costs, the Board of Directors, realizing that only part of the increase can be absorbed in operating expenses, is making a slight adjustment in annual charges to members, and at the same time is raising the sales price of the Book.

For the 1949 Book, Part II will be split into new Parts 3 and 4. Parts I-A (Ferrous Metals) and I-B (Non-Ferrous Metals) become new Parts 1 and 2, with no change in respective contents of fields covered. Parts III-A and III-B covering Nonmetallic Materials—General become new Parts 5 and 6, with only one change in contents, namely that sections covering Adhesives and Shipping Containers now in Part III-B are transferred to new Part 4.

The new Parts 3 and 4 will cover the field of Nonmetallic Constructional Materials, divided into the following sections:

Part 3:

Cement
Concrete, Aggregates, and Nonbituminous Road Materials
Refractories
Glass
Other Cementitious Standards
Bituminous Road and Waterproofing Materials
Oils
General Test Methods

Continued from page 8)

According to one recommendation committee reports would be published separately from the technical papers in a paper-bound volume, possibly distributed to members only on request, but will not be instituted at the present time, pending opportunity for further consideration in the light of a proposal that changes be made in the Society's procedures for receiving and acting upon committee reports. Greater use will be

Part 4:

Paint and Naval Stores
Wood and Wood Preservatives
Adhesives
Shipping Containers
Fire Tests of Materials
General Test Methods

The '49 edition will be about 20 per cent larger than the 1946 Book. The increase in cost of printing, since the '46 edition, has in two years amounted to 20 per cent; so that even with no further increase in costs in 1949 the combination of increased size and increased printing costs will result in the higher cost of approximately 45 per cent, referred to above, which includes the costs entailed in binding and mailing an additional part.

While some of the increased cost can be absorbed in the normal operating expenses of the Society, the Board of Directors feels obliged to make a nominal increase in the annual charges to members who obtain more than one part of the Book of Standards through their membership. Accordingly, effective January 1, 1949, the following charges have been established:

For 1949 Standards (also '50, '51 Supplements)	Annual Charge
Any one part.....	No charge
Any two parts.....	\$4
Any three parts.....	\$5
Any four parts.....	\$8
Any five parts.....	\$10
All six parts.....	\$12

The new scale in general represents an increase of only \$2 for those members (about half of our members) who have been getting two or more parts including the present Part II, and who will now wish to get each of the books into which Part II will be divided, that is, new Parts 3 and 4. Thus, members who wish to continue to obtain the complete Book of Standards will pay \$12 instead of the present \$10. In the case of members

who have been obtaining Part II *only*, without charge, and will now wish to procure both the new Parts 3 and 4, there will be an annual charge of \$4, just as there has been a like charge for the past two years to all members who had originally secured former Parts I or III when each of those parts was split in 1946 into two books.

Members are requested to review their requirements in the light of the foregoing information and to advise the Executive Secretary of any change to be made in their instructions now on file concerning the parts desired. The experience in 1946 when the Book of Standards was changed from three to five parts indicates that the large majority of members will wish to continue receiving the same technical material they have been obtaining, irrespective of how published. Acting on this assumption and unless otherwise advised we will send to the members those parts of the 1949 edition corresponding to present instructions respecting the current edition of the Book of Standards and its Supplements, and will bill the member accordingly on January 1, 1949. This will mean the sending of new Parts 3 and 4 to those members who have been receiving Part II, and sending all six parts of the new edition to members who have been receiving all five parts of the present edition. Any change in instructions received from the members will, however, be recorded and the billing adjusted accordingly.

NOTE: Concerning sales prices for the 1949 Book of Standards, a list price of \$54 for the six parts has tentatively been established. This compares with the present price for the 1946 Book, of \$44. Members will of course receive the usual discounts for extra copies purchased. Further announcements will be made on these and related details.

made of the BULLETIN, however, for the publication of progress reports on specific phases of the work of the technical committees.

As to Standards:

The loose-leaf and loose-unit systems of publication of the Book of Standards, after a very exhaustive study, including the financial considerations involved, have been rejected as not practicable. The advantages that are usually cited

for such methods of publication cease to exist when, as is the case with A.S.T.M. standards, as much as one-fourth of the body of standards may be revised annually; and the disadvantages are considered to be so weighty as to warrant no further consideration of such methods.

Such a scheme would appear to entail less printing and thus result in a saving of paper and time, on the score that it would be necessary to print only the revised and new material each year

thereby eliminating the preparation of the complete Book of Standards every two or three years which includes a certain amount of standing material. Each owner of the Book of Standards would simply remove the out-of-date standards and insert the new ones. The plan has worked successfully in the case of some organizations.

Comparative cost data predicated on a six-year period (which should be the maximum any given binder could be used) showed, however, that in the case of A.S.T.M. such a plan would actually result in increased printing and handling costs. This is due primarily to the relatively large turnover in A.S.T.M. standards. The new or replacement material averages about one-third of the book each year. Added to this is the fact that a number of complete new books must be made available each year for new members and for sale, which means a relatively large advance accumulation of loose sheets or parts. Changes in any of this material would involve the waste of throwing away thousands of pages.

At the present time, five volumes of A.S.T.M. standards are issued triennially in bound form and paper-bound supplements are issued during the second and third years. There are also now 22 compilations of selected standards which are issued annually, biennially, or triennially (although the present trend is toward annual publication). The portion of the present Books of Standards covered by these compilations is as follows:

- Part IA, 1 compilation, approximately 25 per cent
- Part IB, 4 compilations, approximately 75 per cent
- Part II, 7 compilations, approximately 80 per cent
- Part IIIA, 5 compilations, approximately 90 per cent
- Part IIIB, 5 compilations, almost 100 per cent

The present method of publication necessitates repaging and double handling both at Headquarters and at the printer's on all standards which appear in both the compilations and the Book of Standards.

The fact that a considerable portion of the Book of Standards is now covered by compilations with an increasing trend on the part of the various committees to publish the standards under their jurisdiction in compilation form suggests that the compilations might be used as the basic form for the publication of standards and that the bound volumes could be then printed by overrunning the individual compilations. Such a

scheme would involve binding together these overrun compilations of standards.

Arrangements of standards within the compilations could either be on a classified basis or in numeric sequence. A general table of contents would appear in the front of the volume in which all standards and tentatives would be listed in the sequence in which they appear in the book as well as a table of contents arranged in numeric sequence, although in either event the standards and tentatives would be merged, which is a departure from the present method of publishing the Book of Standards, in which they are segregated. A complete subject index would also be included at the back of the book to facilitate finding a given standard. On this basis the printing of the various volumes could be combined with existing compilations at less cost and considerable saving in time over the method now used.

Specifically, it is proposed that the Book of Standards be issued in 1949 as six parts, as indicated in the accompanying Table I. This recommendation is premised on the fact that the present Part II is now approaching a size at which the amount of material contained therein is too bulky for economical binding or convenient handling. In order to indicate that each volume is a separate entity, the parts will be numbered from one to six rather than 1A, 1B, etc.

TABLE I.—SUGGESTED ARRANGEMENT OF 1949 BOOK OF STANDARDS

PART 1.—FERROUS METALS

- *Section A—Steel Pipe and Piping Materials (A-1)
- Section B—Other Ferrous Standards
- Section C—General Test Methods

PART 2.—NON-FERROUS METALS

- *Section A—Electrical Resistance Materials (B-4)
- *Section B—Copper and Copper Alloys (B-1 and B-5)
- *Section C—Light Metals (B-7)
- *Section D—Electrodeposited Coatings (B-8)
- Section E—Other Non-Ferrous Standards
- Section F—General Test Methods

PART 3.—CEMENTITIOUS, SOILS, ROADS AND WATERPROOFING MATERIALS

- *Section A—Cement (C-1)
- *Section B—Concrete and Non-Bituminous Road Materials (C-9 and D-4)
- *Section C—Refractories (C-8)
- *Section D—Glass (C-14)
- Section E—Other cementitious, etc., Standards
- *Section F—Bituminous Road and Waterproothing Materials (D-4 and D-8)
- *Section G—Soils (D-18)
- Section H—General Test Methods

PART 4.—PAINT, WOOD, ADHESIVES, SHIPPING CONTAINERS

- *Section A—Paint and Naval Stores (D-1 and D-17)

Section B—Wood and Wood Preservatives (D-7)

*Section C—Adhesives

Section D—Shipping Containers

Section E—Fire Tests of Materials

Section F—General Test Methods

PART 5.—NON-METALLIC—FUELS, PETROLEUM, AROMATIC HYDROCARBONS, SOAP, WATER TEXTILES

- *Section A—Petroleum Products and Aromatic Hydrocarbons (D-2 and D-16)
- Section B—Gaseous Fuels (D-3)
- *Section C—Coal and Coke (D-5)
- *Section D—Soap (D-12)
- *Section E—Textiles (D-13)
- *Section F—Water (D-19)
- Section G—General Test Methods

PART 6.—NON-METALLIC MATERIALS, ELECTRICAL INSULATION, PLASTICS, RUBBER, PAPER

- *Section A—Electrical Insulating Materials (D-9)
- *Section B—Plastics (D-20)
- *Section C—Rubber Products (D-11)
- *Section D—Paper and Paper Products (D-6)
- Section E—General Test Methods

The proposal to take advantage of compilations will save much repaging, as indicated, and will save considerable time at the printer's as well as staff time and should materially expedite publication of standards and committees. At the present time without duplicate paging required, compilations can only be issued early by delaying publication of the Book of Standards or *vice versa*, and to satisfy all members of the Society simultaneous publication is desirable. This system also has the advantage that should annual publication be desirable, very little change will be necessary in publication practice and a minimum amount of staff work will be required because of the increasing tendency for all standards to appear in combination form.

The various proposals are outlined in greater detail in the Annual Report of the Board of Directors and much of the information is recorded there. Members may wish to refer to this for more extended discussion of the recommendations on future publication policies.

The Papers Committee and the Fuels Committee are indebted to those who served on the two study committees who made the analysis and very exhaustive studies upon which the recommendations referred to above are based:

Committee on Standards

- G. R. Gohn, Chairman
- J. C. Geniesse

Committee on Technical Papers

- P. G. McVetty, Chairman
- G. R. Gohn
- K. B. Woods

* Published also as compilations of Standards.

Several New Technical Books and Compilations Issued

Progress Being Made on Heavy Publication Schedule

Notes on New Books

SATISFACTORY progress is being made in the issuance of a large number of books listed in the 1948-1949 A.S.T.M. publication schedule. Some details of a large number of books to be issued are noted in the August BULLETIN and in the accompanying box notes on technical publications and special compilations of standards that have been issued or are anticipated in the very near future.

While there will be distributed to each member and committee member of the Society about November 15, a special blank and a new List of Publications, some members may wish to order copies of available books now. Shipping, of course, will be made just as far as possible.

Forum on Tractor Fuels (STP 82)

The papers and discussion comprising the January, 1948, symposium were intended to bring out various viewpoints on a number of problems in connection with requirements for tractor fuels. With the tremendous growth in mechanization of farms and the use of tractors in so many branches of industry there have been a variety of tractors produced. The increase in volumes of fuel required together with different operating conditions and on top of this Government regulations have created some real problems. A.S.T.M. Committee D-2 on Petroleum Products and Lubricants, through its Division on Tractor Fuels, felt that discussion would be desirable and sponsored this Forum. There are technical papers which have been condensed essentially as presented by the speakers. The publication departs somewhat from the usual type of formal A.S.T.M. technical symposium, but is nevertheless very pertinent with helpful information set forth and is interesting reading.

Copies of the publication aggregating 43 pages, in heavy paper cover, can be obtained by members at 75 cents, the price being \$1.00.

Symposium on Mineral Aggregates (STP 83)

This was the most extensive symposium at the 1948 Annual Meeting. Many of the country's leading authorities participated, either as part of the Symposium Committee, a joint group under the auspices of Committee C-9 on Concrete and Concrete Aggregates and Committee D-4 on Road and Paving Materials, or as authors of the technical papers.

In the introduction, Prof. K. B. Woods, Purdue University, Chairman of the Symposium Committee, points out that the group of papers and extensive discussions deal with the distribution, characteristics, and uses of mineral aggregates. "The papers in this symposium are written primarily for that group of individuals interested in the characteristics and uses of mineral aggregates who normally are not intimately connected with the aspects of research and testing. For purposes of the symposium, mineral aggregate may be defined as 'Mineral Aggregate—An aggregation of sand, gravel, crushed stone, slag, or other material of mineral composition, used in combination with a binding medium to form bituminous and portland-cement concrete, macadam, mastic, mortar, plaster, etc., or alone as in railroad ballast, filter beds and various manufacturing processes, such as fluxing, etc.' It is to be noted that the concept embodied in the use of the term 'aggregate' as presented in his definition is much more inclusive than that of either of the present A.S.T.M. definitions."

It is further noted that the last major symposium on this subject, mineral aggregates, was almost twenty years ago in 1929, and since that time the enormous demand for mineral aggregates as a material for construction has stressed the need for complete up-to-date information on the characteristics of aggregates. Quoting again from Professor Wood's symposium discussion, "Even though the scope of this symposium is enlarged considerably over that presented in 1929, there are many subjects which have been

touched upon only lightly. In contrast, many of the papers contain extensive bibliographies. Historical background has been presented where it is indicated that this phase of the subject is important in evaluating current practices. The papers may be grouped into six general categories including: (1) Distribution, Processing, and Sampling; (2) Tests and Mineralogical Characteristics; (3) Aggregates for Portland-Cement Concrete; (4) Aggregates for Bituminous Construction; (5) Aggregates for Miscellaneous Use; and (6) Needed Research."

The complete list of papers and names of authors follows; it will be apparent from this list that the symposium is indeed an extensive one, and that many authorities have contributed of their knowledge, and time, and effort to this publication.

Introduction—K. B. Woods, Purdue University

Distribution of Mineral Aggregates—

K. B. Woods, Purdue University
Petrographic and Mineralogic Characteristics of Aggregates—Roger Rhoades and Richard C. Mielenz, Bureau of Reclamation

Physical and Chemical Tests and Their Significance—Harold S. Sweet, Joint Highway Research Project, Purdue University

Sampling of Mineral Aggregates—C. E. Proudley, North Carolina State Highway and Public Works Commission
Production and Manufacture of Fine and Coarse Aggregates—Nathan C. Rockwood, Rock Products, Maclean-Hunter Publishing Co.

Grading of Aggregates for Bituminous Construction—Jewell R. Benson, Bureau of Reclamation

Books Off Press or to Be Available Soon

TECHNICAL PUBLICATIONS

- Forum on Tractor Fuels
- Symposium on Spectroscopic Light Sources
- Symposium on Mineral Aggregates
- Symposium on Ball-Bearing Greases

BOOK OFF PRESS ABOUT

- October 5
- November 15
- November 15
- December 15

BOOK OFF PRESS ABOUT

- Week of September 27

Week of October 4

Week of October 4
Week of October 11

Week of October 18
Week of November 8

Week of November 8
Week of November 15

- SPECIAL COMPILATIONS OF STANDARDS
- Plastics (D-20)
- Mineral Aggregates, Concrete, and Non-bituminous Highway Materials (C-9—D-4)
- Electrical Heating and Resistance Materials (B-4)
- Textile Materials (D-13)
- Bituminous Materials for Highway Construction, Waterproofing and Roofing (D-4—D-8)
- Paper and Paper Products (D-6)
- Copper and Copper Alloys, Cast and Wrought (B-5)
- Petroleum Products and Lubricants (D-2)

Influence of Mineral Aggregates on the Strength and Durability of Concrete—C. W. Allen, Ohio State Department of Highways

Grading of Mineral Aggregates for Portland Cement, Concrete, and Mortars—Walter H. Price, Bureau of Reclamation

Lightweight Aggregates—R. E. Davis and J. W. Kelly, University of California

Mineral Aggregates for Bituminous Construction—J. T. Pauls and C. A. Carpenter, Public Roads Administration

Mineral Aggregates for Low-Cost Roads and Water-Bound Macadams—Edwards A. Willis and James A. Kelley, Jr., Public Roads Administration

Mineral Aggregates for Railroad Ballast—A. T. Goldbeck, National Crushed Stone Association, Inc.

Mineral Aggregates in the Chemical and Processing Industries and in Certain Other Uses—Herbert F. Kreige, The France Stone Company

Needed Research—D. O. Woolf, Public Roads Administration

Copies of this 240-page publication, heavy paper cover, can be procured by members at \$2.25 each; list price, \$3.00; cloth cover \$2.90 and \$3.65, respectively.

Symposium on Spectroscopic Light Sources (STP 76)

Several factors delayed the publication of this interesting and significant symposium, which was held at the 1946 A.S.T.M. Annual Meeting, but now that it definitely will be available in a few weeks all those who have ordered copies will be receiving them soon. Others concerned will find the publication of much interest and value.

Sponsored by Committee E-2 on Spectrographic Analysis, the symposium includes four formal technical papers, together with prepared discussions. The discussions come from those who have been very active in this field.

In his introduction to the symposium E. B. Ashcraft, Monsanto Chemical Co., writes as follows: "This symposium was, organized with the thought in mind that the time has arrived when the field of spectrochemical analysis can best be advanced by a detailed examination of its various subdivisions. The techniques and instruments used in spectrochemical analysis divide themselves more or less naturally into three groups having to do, respectively, with the excitation of the sample, the resolution of the spectrum, and the determination of the relative intensities of the light emitted at various wave lengths. It was thought by the committee that the first of these groups is perhaps the least advanced and that a detailed study in the form of a symposium might be a particularly desirable contribution at this time."

Following the introduction, the four extensive papers are given with discussions. These papers cover:

The Present Status of Excitation in Spectrographic Analysis—B. F. Schibner, National Bureau of Standards

A Study of the Controlled Spectrographic Spark Source—J. H. Enns and R. A. Wolfe, University of Michigan

Some Properties of Gas Discharges Used as Spectral Sources—R. C. Mason, Westinghouse Research Laboratories

Short-Period Phenomena in Light Sources—G. H. Dieke, The Johns Hopkins University

Publication Order Blanks

Each member and committee member will receive about November 15-20 a special order blank, and descriptive material covering the new and many of the older publications. While many will wish to order books in advance, the members' order blanks with the special prices to members, and the committee form will be convenient in transmitting orders for the desired books.

This 90-page book, in heavy paper cover, can be procured by members \$1.50; list price to nonmembers, \$2.00.

Symposium on Functional Tests for Ball-Bearing Greases (Reprint from Proceedings)

This symposium should be ready for distribution about December 15, but date is approximate only. This interesting session at the 1948 Annual Meeting was sponsored under the auspices of Committee D-2 on Petroleum Products and Lubricants, specifically, its Technical Committee G on Lubricating Greases. A statement on the background for the symposium, and its purposes, together with list of the papers and authors, follow:

The soundness of the principle of performance evaluation of greases has generally accepted, but agreement on procedures for such evaluation has not been reached. In an effort to standardize such tests for ball-bearing greases, a committee of the Society has found a variety of methods from which to choose. To their selection, this symposium has been arranged so that users of several methods can describe the degree of their success.

The authors represent a variety of interests in the subject. One paper is from a grease manufacturer; one, from a machinery manufacturer; a third, from a company using grease only for lubrication of production machinery; another, from an association of manufacturers interested in lubrication of their product; and the last, from a consumer which manufactures some of its machinery but needs to lubricate it. From these diverse attacks on the problem and the discussion of the progress made in each, it is hoped to derive information which will lead to enlightened standardization of functional tests for ball-bearing greases.

Development of Functional Grease Methods for Aircraft Industry—I. Moreton, Douglas Aircraft Co.

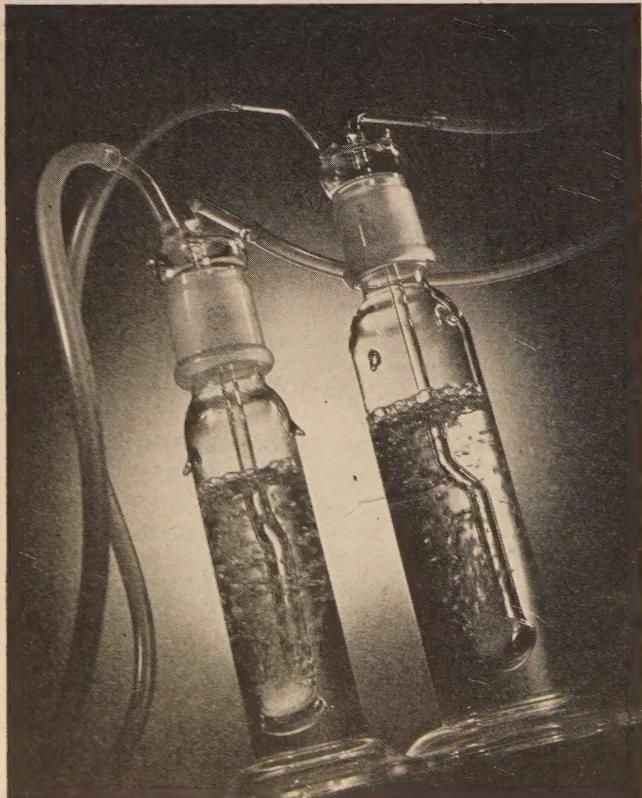
Grease—An Oil Storehouse for Bearings—D. F. Wilcock and M. Anderson, General Electric Co.

Laboratory Performance Tests for Friction Bearing Greases—M. H. W. A. Prendergast, R. S. Bainbridge, W. J. Finn, and O. P. Puryear, Texas Company

Service Experience with Grease—Pope and W. T. Everitt, Eastman Kodak Co.

Factors Affecting Simulated Service Tests of Greases—Sidney M. Colman and John R. Belt, U. S. Engineering Experiment Station

This 104-page symposium, heavy paper cover, will be available at \$1.25 to members; list price to nonmembers \$1.75.



"Wash Bottles"

First prize-winning photograph, General Section, Testing Equipment Group, in the Sixth A.S.T.M. Photographic Exhibit, by John Kalinich, Corning Glass Works.

Special Compilations of Standards

OF THE several special compilations of standards to be issued during the next few months, a few have been completed and others are scheduled for October and November. Exact dates when the books will be off press cannot be given because of several factors involved.

These special compilations have come into great significance in the particular industries where the respective specifications and tests are used. They give compact form practically all of the A.T.M. standards which are of major interest to the particular industries, and several of the books include other useful information—tables, charts, final reports and such items—which committees responsible consider will be very helpful in the work on materials. Decisions on what standards shall go into a particular compilation and what complementary material should be included are made by the technical committees sponsoring the various books, usually through a publication committee. The interest of the committees has been invaluable, and the extent of use of each of the compilations previously issued is an indication of the value of these publications.

Standards on Textile Materials:

When the first edition of this book was issued in the early 1920's its introduction into the industry seemed rather slow, but it has now come into very widespread use and reflects the interest of the industry in quality and in testing. Committee D-3 on Textile Materials which sponsors this book is one of the Society's largest and most active. Since a list of the 13 subcommittees will also convey some idea of the materials and subjects covered in the compilation of standards, the list follows:

- Cotton and Its Products
- Rayon and Other Synthetic Fibers
- Wool and Its Products
- Asbestos and Its Textile Products
- Bast and Leaf Fibers
- Household and Garment Fabrics
- Glass Fiber and Its Products
- Fire Cord and Fabrics
- Felt
- Pile Fabrics
- Iosiry
- Knitted Fabrics (in course of organization)
- Methods and Machines
- Nomenclature and Definitions
- Bleaching, Dyeing and Finishing
- Sampling, Presentation and Interpretation of Data
- Significance of Tests

The 1948 Textile Compilation includes most 90 specifications, test methods, definitions, recommended practices, etc., of course, being given in their latest proved form. In addition to these standards there are tables for relative humidity, photomicrographs of textile

fibers and of defects in woven fabrics, yarn number conversion tables, glossaries of terms, etc. Several proposed methods not yet approved by the committee or the Society are given, and this year there are technical papers covering the stress-strain curve, applications of stress-strain measurements and the importance of the time factor in the study of fibers.

Copies of this 560-page book in heavy paper cover can be procured by members at \$3.25 each, the list price being \$4.35. Reduced prices are in effect on orders in quantity.

Compilation of Standards on Plastics:

This book came off press in September, 1948, and while it represents one of the relatively newer activities of the Society, Committee D-20 having been in existence now for only about ten years, the fact that the book has over 100 standard specifications and test methods and sets of definitions of terms, and covers over 600 pages, to some extent indicates the intensive A.S.T.M. work in this field. The approximately 30 specifications cover a wide range of molding compounds and forms of plastics produced from the various plastic families—

phenolics, melamines, allyls, vinyl chlorides, cellulose, and the like. The test methods which have resulted from intensive work in the committee, frequently involving a series of research investigations and round-robin tests, relate to the various important properties of plastics—strength, hardness, thermal properties, optical, permanence, etc.

In addition to the work of Committee D-20 on Plastics, Committee D-9 on Electrical Insulating Materials has developed a number of standards covering the plastics used in its field, and these are given in this book.

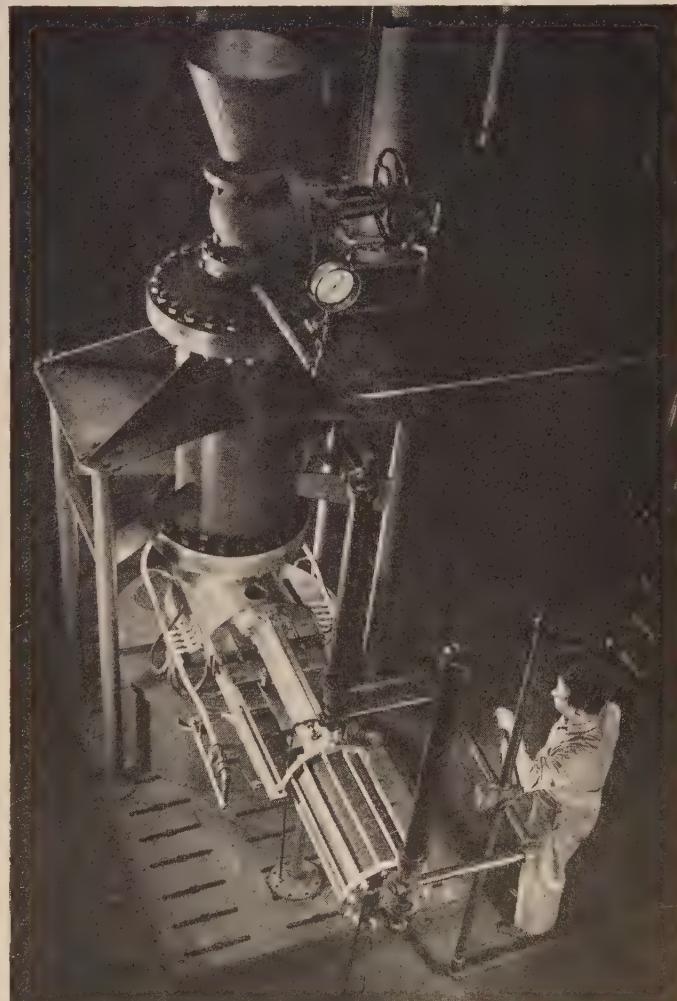
Copies can be procured by members at \$3.40 each, the list price being \$4.50.

Electrical Heating, Resistance, and Related Alloys:

This compilation while not nearly so extensive as those which cover the fields of plastics or petroleum or textiles, nevertheless is of vital significance to all those companies and individuals who are concerned with electrical resistance and electrical heating alloys, materials for radio tubes and lamps, heat-resisting and thermostat metals, and the like. Committee B-4 is concerned with life tests, electrical and mechanical tests, and such problems. It has a very active and large subcommittee

"Simulated Service Test on Large Valves"

First prize-winning photograph, General Section, Simulated Service Testing Group, in the Sixth A.S.T.M. Photographic Exhibit, by William W. C. Wilke, Jr., Crane Co. Research Laboratories.



dealing with metallic materials for radio tubes and incandescent lamps, and in all has in its jurisdiction upwards of 40 standards.

This book is available to members at \$1.75, the list price being \$2.25.

A. Mineral Aggregates, Concrete, and Nonbituminous Highway Materials; B. Bituminous Materials for Highway Construction, Waterproofing and Roofing:

These two compilations issued for the first time in their new form in the Fall of 1948 have resulted from studies by the three committees chiefly concerned: C-9 on Concrete and Concrete Aggregates, D-4 on Road and Paving Materials, and D-8 on Bituminous Waterproofing and Roofing Materials. While there is overlapping interest in these fields it was quite evident that two books were desirable, one covering the concrete and concrete aggregates and nonbituminous highway materials, and the other relating specifically to bituminous materials.

The "Aggregates and Nonbituminous" compilation gives all of the standards developed by Committee C-9, but only those on nonbituminous highway materials under the jurisdiction of Committee D-4. It also includes pertinent specifications for cement for which Committee C-1 is responsible. Thus the "C-9—D-4" book (a short convenient handle to describe the book) has numerous specifications and tests for aggregates and concrete and cement, and certain miscellaneous related standards.

THE "Bituminous" compilation is the larger of these two books aggregating some 320 pages, with over 90 specifications, tests, recommended practices, etc. There is a large group of specifications for various types of bituminous materials used in highway construction; and another group giving quality requirements

for waterproofing and roofing materials—shingles, asphalts, felts, coal-tar pitch, etc., creosote specifications and an extensive series of tests. The book is complete with definitions of terms relating to materials for roads, and timber preservatives.

The C-9—D-4 compilation is priced to members at \$1.75; list price \$2.25. The D-4—D-8 compilation (bituminous materials) can be procured by members at \$2.25; list price \$3.

Standards on Copper and Copper Alloys:

A.S.T.M. has been conducting standardization and research work in the field of copper and copper alloys since at least 1909. Always there has been close cooperation between consumers and producers to develop new test methods and specifications as required and to keep existing standards up to date. The work of A.S.T.M. Committee B-5 on Copper and Copper Alloys is always of importance, but it was never so essential as during the last war. The committee cooperated on many important projects with various branches of the Government.

The compilation of standards which it sponsors includes not only the tests and the purchase specifications in its charge, but also the numerous wire and cable specifications developed by Committee B-1 on Wires for Electrical Conductors, and a number of non-ferrous metals requirements which are in the scope of Committee

B-2 on Non-Ferrous Metals and Alloys

This latest 1948 "B-5" compilation—a large number of new, and numerous revised 1948 standards came off press early October.

Members can obtain this valuable widely used book, heavy paper cover, aggregating 516 pages, at \$3.25 members' price; \$4.35 list price.

1948 Standards on Paper and Paper Products

The fourth edition of this helpful compilation of standards, issued under the auspices of A.S.T.M. Committee D-1 on Paper and Paper Products, is considerably more extensive than earlier publications, with new standards included. Paper is used in such a variety of products and in so many different ways, that one would expect many different kinds of tests would be necessary to evaluate the properties depending upon their use. One finds in the large number of standardized test procedures in the book those covering crease resistance, flammability, folding endurance, tensile strength, wet curl, etc. Several of the tests relate to specific products, such as bags, shipping containers, electrical insulating materials, and the like. There is a series of definitions of terms relating to shipping containers, and there are seven specifica-

The members' price for this 272-page book, heavy paper cover, is \$1.90 members' price \$2.50.

Metals

- High-Temperature Properties of Rotar Disks for Gas Turbines as Affected by Variables in Processing—H. C. Cross, Ward F. Simmons, J. W. Freeman, and E. E. Reynolds
An Investigation of the Possibilities of Organic Coatings for the Prevention of Preventive Corrosion Fatigue Failures in Steel—Robert C. McMaster
Some Aspects of the Effect of Metallurgical Structure on Fatigue Strength and Mechanical Sensitivity of Steel—T. J. Dolan and C. S. Yen
Fatigue and Static Load Tests of an Austenitic Cast Iron at Elevated Temperatures—W. Leighton Collins
Tensile, Creep, and Fatigue Properties at Elevated Temperatures of Some Magnesium Base Alloys—John C. McDonald
An Hypothesis for the Determination of Accumulative Damage in Fatigue—F. E. Riedel Jr., and N. M. Newmark
Changes Found on Reciprocated Steel; Chrome Plate, and Cast Iron Sliding Surfaces—J. N. Good and Douglas Godfrey
Symposium on Deformation of Metals as Related to Forming and Service Panel Discussion on the Influence of Non-Ferrous Metals and Their Compounds on the Corrosion of Pressure Vessels

Cement, Concrete, Aggregates, Masonry Materials, Soils

- The Spectrochemical Analysis of Cements and Other Mineral Products—M. F. Hirsch, C. E. Harvey, and F. W. Barley
The Effect of Repeated Loading on the Bond Strength of Concrete—Supplement—C. W. Muhlenbruch
Research on Concrete Durability as Affected by Coarse Aggregate—Harold S. Sorenson
The Determination of Limits for the Control of Placement Moisture in High-Earth Dams—W. G. Holtz
The Importance and Practical Use of Relative Density in Soil Mechanics—Donald L. Burmister
Symposium on Methods and Procedures Used in Identifying Reactive Materials in Concrete

Petroleum Products and Lubricants, Plastics, Miscellaneous, General

- Bearing Corrosion Tests Using the MacCoul Tester and a Study of the Kinetics of Oxidation—Hugh R. Lehman and L. K. Herndon
The Effect of Temperature on Creep of Laminated Plastics—W. N. Findley, W. J. Vining, and C. N. Adams
Measurement of the Reactivity of Solid Fuels by the Crossing-Point Method—J. J. P. Cohen, R. Corey, and B. Jain
Symposium on Speed of Testing
Symposium on Usefulness and Limitations of Samples

New Books in A.S.T.M. Technical Series

A DETAILED announcement of the establishment of an A.S.T.M. Technical Series with the assignment of technical publication numbers to various books was given in the May, 1947, BULLETIN. This article noted since 1911, when there was published the book "The Life and Life Work of Charles B. Dudley," many books and pamphlets have been issued, which were not included in the Proceedings, BULLETIN, or Book of Standards.

Since the publication of the list, which included 71 items, a number of other books and pamphlets have been issued, and the following list notes these and again publications scheduled to appear during the balance of 1948. These technical publication numbers (s) are used in the List of Publications, and the numbers can be used in referring and identifying the various books. However, the best procedure, as in the case with the separate copies of standards, is to give the number and title.

- TP 72 Symposium on Testing of Parts and Assemblies (1947)
- TP 73 Symposium on pH Measurement (1947)

- TP 74 Symposium on Rubber Testing (1947)
- TP 75 Symposium on Paint and Paint Materials (1947)
- TP 76 Symposium on Spectroscopic Light Sources
- TP 77 Symposium on Synthetic Lubricants (1947)
- TP 78 Symposium on Effects of Low Temperature on Materials
- TP 79 Symposium on Load Tests of Bearing Capacity of Soils (1947)
- TP 80 Number assigned but not used
- TP 81 Petroleum Products as Related to Automotive Equipment (1947)
- TP 82 Symposium on Tractor Fuels (1948)
- TP 83 Symposium on Mineral Aggregates (1948)
- TP 84 Symposium on Ball Bearing Greases (1948)
- TP 85 Symposium on Magnetic Testing (1948)
- TP 86 Symposium on Metallography in Color (1948)

Meeting of Society for Applied Spectroscopy

ANNOUNCEMENT has been received from Professor Henry H. Hausner, New York University, Room 108, Nichols Building, University Heights, of a series of meetings to be held at the Lecture-Hall, Old World Building, 63 Park Row, New York City, dealing with various aspects of Applied Spectroscopy.

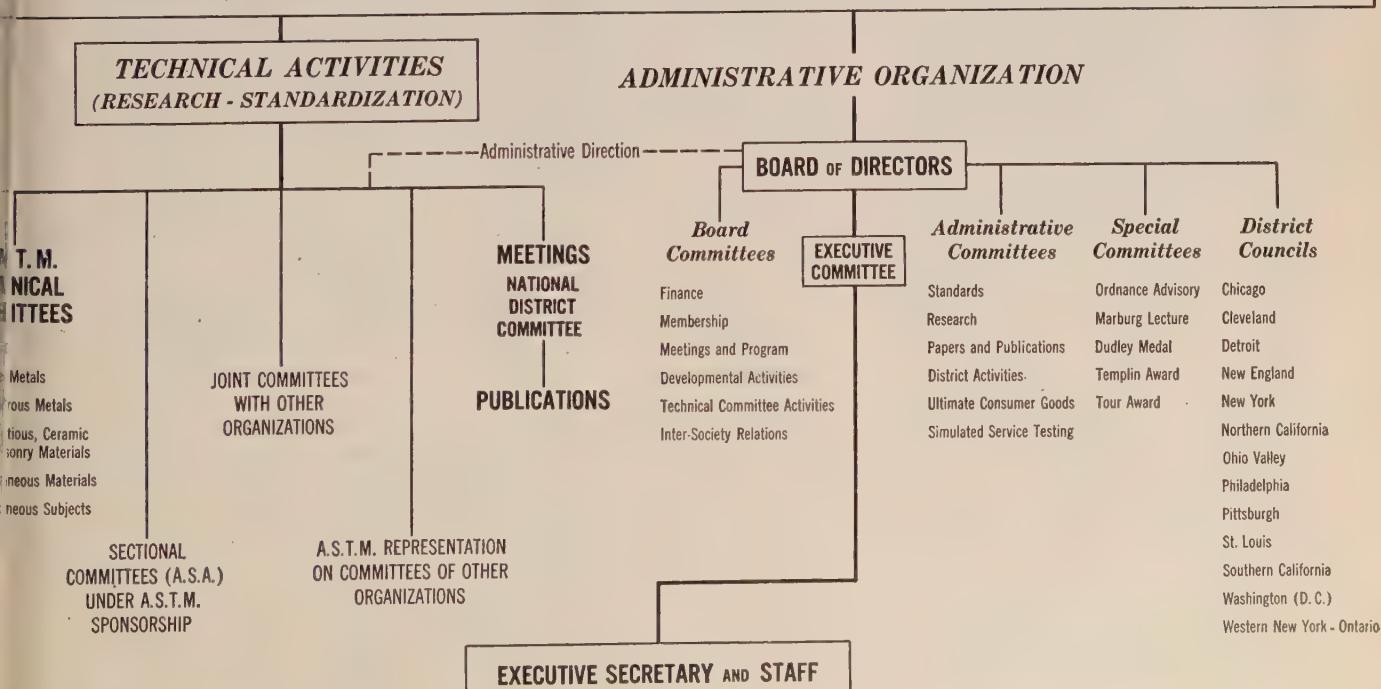
Meetings are to be held on November 9, December 7, January 4, and February 1 with prominent men in their field as speakers. Details of the meetings can be obtained by writing to Professor Hausner.

Activities and Organizational Chart

THE accompanying chart giving a general broad outline of the A.S.T.M. technical activities and administrative organization may be of interest to many of the members and BULLETIN readers. The chart will be a part of the general information section of the forthcoming Year Book and is intended to show how the work is channeled.

Regardless of the apparent fact (to which the editors subscribe) that no reasonable chart can portray all the activities of A.S.T.M., it was felt desirable to attempt a visual portrayal.

AMERICAN SOCIETY FOR TESTING MATERIALS





OCTOBER 1948

NO. 154

NINETEEN-SIXTEEN
RACE STREET
PHILADELPHIA 3, PENNA.

Technical Program for 1949 San Francisco Meeting Being Developed

PLANS for the technical program of the Society's 1949 Pacific Coast meeting are rapidly taking shape under the guidance of the Committee on Technical Program, of which Professor R. E. Davis, University of California, is Chairman. At its first meeting last spring the committee outlined a program comprising twelve sessions, and at its second meeting recently in Berkeley it received reports of progress on the assignments of the various committee members. The subjects which the committee are developing for the technical program include: metals, with particular reference to fatigue, creep and formability properties; cement, concrete, asphalt and soils, especially in relation to highway and airport construction; petroleum; paint, including a seminar discussing the activities of the Society's Committee D-1 in the paint field; manufactured masonry units; timber; dynamic stress measurements; and applications of statistical analysis.

As announced in the May BULLETIN, the first national meeting of A.S.T.M. on the Pacific Coast will be held in San Francisco, Monday through Friday, October 10-14, 1949. Convention headquarters will be at the Fairmont Hotel. The technical sessions will be spread over four days and there will be various open periods for recreation and entertainment, pleasure trips, visits to industrial plants and other activities. It is expected that some of the Society's technical committees will participate in the meeting by holding committee and subcommittee meetings there. A banquet is planned for Wednesday evening of the meeting week.

Following is the personnel of the Committee on Technical Program:

R. E. Davis, Professor of Civil Engineering and Director, Engineering Materials Laboratory, University of California, Berkeley, *Chairman*
J. W. Kelly, University of California, Berkeley, *Secretary*

Engineer, Simons Brick Co., Los Angeles
L. A. O'Leary, Head, Chemical Engineering and Research Dept., W. Fuller and Co., South San Francisco
T. E. Stanton, Materials and Research Engineer, California Div. of Highways, Sacramento
Fred D. Tuemmler, Head, Analytical Standardization Dept., Shell Development Co., Emeryville
C. M. Wakeman, Testing Engineer, City of Los Angeles Harbor Department, Wilmington
H. A. Williams, Associate Professor, Civil Engineering, Stanford University

Other committees will be appointed to take charge of other phases of meeting covering such matters as hotels, registration, transportation, entertainment, visits to industrial plants, banquet, publicity, and finances. These committees will function under the direction of a General Committee on Pacific Coast Meeting which will be in overall charge of arrangements. Announcement of appointments to these committees and of the various features of the meeting as they are developed, will be made in future issues of the BULLETIN.

Plan to Be in San Francisco, October 10-14, 1949

Schedule of A.S.T.M. Meetings

DATE	GROUP	PLACE
October 26, 27, 28, 29	Committees C-1, C-7, C-9, and D-4	St. Louis, Mo.
October 26	New York District Meeting	New York, N. Y.
October 27	Committee B-7-Special	(A.S.T.M. Headquarters)
October 27	Committee on Corrosion	
October 27	Executive Council-E-7 on Radiographic Testing	(A.S.T.M. Headquarters)
October 28, 29	Committee D-15 on Engine Antifreezes	Washington, D. C.
October 29	Committee E-3 on Chemical Analysis of Metals	(A.S.T.M. Headquarters)
November 1	Administrative Committee on Papers	(A.S.T.M. Headquarters)
November 3, 4, 5	Committee B-5 on Copper and Copper Alloys, Cast and Wrought	(A.S.T.M. Headquarters)
November 4	St. Louis District Meeting	St. Louis, Mo.
November 10	Philadelphia District Meeting	Franklin Institute, Philadelphia
November 10, 11, 12	Committee D-14 on Adhesives	Washington, D. C.
November 13-17	Committee D-2 on Petroleum Products and Lubricants	Chicago, Ill.
November 16	Cleveland District Meeting	Cleveland, Ohio
November 16, 17	Committee D-20 on Plastics	Atlantic City, N. J.
November 17, 18, 19	Committee D-9 on Electrical Insulating Materials	Atlantic City, N. J.
November 19	Committee C-19 on Structural Sandwich Constructions	(A.S.T.M. Headquarters)
November 19	New England District Meeting	Worcester, Mass.
November 29	Pittsburgh District Meeting	Pittsburgh, Pa.
December 7	New York District Meeting	New York, N. Y.

Interesting District Meetings Planned for Fall and Winter

Subjects: Good Design, Aluminum, House Heating, Philosophy of Specifications, Quality Control, Textile Developments. All Members and Friends Invited

THE first of a series of interesting District Meetings will be held in Philadelphia on Wednesday, October 13, with the first meeting of the Washington (D. C.) District on the following night, October 14, and others to follow as indicated in the accompanying schedule. President Richard L. Templin, Aluminum Company of America, will speak at several of the District Meetings, covering "Aluminum," with particular emphasis on the technical and research developments and a look into the future.

Each of these meetings is planned by the respective A.S.T.M. District Councils to bring before the local members of the Society outstanding speakers in their various fields, to cover subjects which are considered by the respective councils to be timely and pertinent and the general field of the Society's purpose and work.

A number of the meetings are sponsored jointly with local chapters and sections of other national organizations. Frequently our District Councils are in a position to suggest and develop interesting programs, and because some of the topics should be of distinct interest to certain engineering and professional groups, the latter frequently receive special invitations to attend the meeting, and in numerous cases are joint sponsors of the affairs.

Members Cooperation Urged:

Like practically all A.S.T.M. activities, the meetings and other projects sponsored by the 13 A.S.T.M. Districts, are cooperative in nature. Various members of the council are responsible for specific phases of the meeting, and members in the respective districts particularly are urged to attend if feasible. It is believed that no matter what may be a member's industry, or field of interest, he will hear interesting information and derive considerable benefit from the technical sessions. Actually, the meetings have as one of their purposes that being broadly educational.

None of the districts plans a very extensive series of meetings. Thus far Philadelphia with five definitely planned, and New York with four, have the most intensive schedule. Other districts usually hold one or two meetings a year; thus there will not be a heavy demand for members' time at meetings.

An objective of these district meetings is to afford members an opportunity to

meet one another and to make the acquaintance of the officers of the Society, and to realize that even though A.S.T.M. work cuts horizontally across all fields of materials and industry, nevertheless, there is a very considerable community of interest and activity.

Brief Notes on District Meetings:

Good Design—On Purpose: Philadelphia, October 13:

The first of five meetings to be sponsored by the Philadelphia District is to be held at the Franklin Institute on the Parkway, at 8 o'clock on October 13. W. T. Bean, Research Engineer, in Charge of Experimental Stress Analysis, Continental Aviation and Engineering Corp., Detroit, will discuss Good Design—On Purpose. The speaker is very close to this subject and has done some very interesting work on stress analysis and studies of failures of materials. Actually, he plans to point out ways and means of avoiding failures through the elimination of bad designs, which intensify stress and strain. Mr. Bean presented an interesting paper at the 1946 A.S.T.M. Annual Meeting in Buffalo as part of the Symposium on Testing of Parts and Assemblies. Frank G. Tatnall, former Chairman of the Philadelphia District, and widely known to all the A.S.T.M. people, is the evening's Program Chairman.

Aluminum—Five Outstanding Developments in Textiles—Washington, October 14:

The technical session and dinner at the Wardman Park Hotel on October 14 is the first meeting to be sponsored by the Washington (D. C.) District, and it is fitting that the Society's President, Richard L. Templin, should be on the program. He will cover the subject "Aluminum" with some brief comments on history, economics, and applications, but discuss in particular some of the technical and research developments, in many of which he has had an important part, and also note some of the important uses, and take a look into the future.

This meeting is arranged jointly with A.S.T.M. Committee D-13 on Textile Materials, and it is appropriate, therefore, that the subject of textiles be incorporated as the meeting program. Dr. Frederick Bonnet, formerly Director,

Standards Dept., American Viscose Corp., will give a summary of the Five Outstanding Developments in Textiles During the Last Decade, basing his talk on a consensus reached in replies from the members of the Advisory Committee of Committee D-13. This group of some thirty outstanding technologists in their respective fields was circularized and Dr. Bonnet agreed to present the results of the survey.

During the week of the meeting, Committee D-13 is holding its intensive series of fall meetings in Washington.

Dr. Gordon Kline, National Bureau of Standards, is Chairman of the Program Committee, and the officers of the new Washington (D. C.) District Council have handled all of the details for the meetings.

Aluminum—Chicago, October 19:

A.S.T.M. President Richard L. Templin will speak on the subject of "Aluminum," going into the technical and research developments, and a look into the future in the field of aluminum.

This is to be a joint meeting with the Western Society of Engineers, and is to be held in the new headquarters of that organization. Recently the Western Society of Engineers has joined with the John Crerar Library, a long-time member of A.S.T.M., making available new facilities for meetings, etc. The W.S.E. Headquarters are at 84 E. Randolph Street.

V. O. McClurg, president of the W.S.E., will be present at the meeting and will speak briefly.

Don L. Colwell, Apex Smelting Co., as chairman of the Meeting Program Committee, together with George E. Stryker, Bell & Howell Co., District Secretary, has handled the meeting details.

Domestic House Heating—New York, October 26:

Three important phases or developments in the field of house heating are to be covered at the meeting in the Engineering Societies Building by the New York District. H. H. Weber, Chief Engineer, Wire and Cable Dept., United States Rubber Co., will cover Electric Panel Heating. Peter B. Gordon, Treasurer, Wolff & Munier, Inc., will talk on Hot Water Panel Heating, and the third interesting discussion will be on a Heat Pump, given by W. L. Knaus, Engineer,

Air Conditioning Dept., General Electric Co., of Bloomfield, N. J.

Professor Carl F. Kayan of Columbia University is to be the technical chairman.

This meeting should be very interesting and well attended, since it is jointly sponsored with the Metropolitan Section of The American Society of Mechanical Engineers, and the New York Chapter of The American Society of Heating and Ventilating Engineers.

C. A. Hescheles, United States Rubber Co., is Meeting Chairman, with S. R. Doner, Raybestos-Manhattan, Inc., serving as General Program Chairman for the A.S.T.M. N. Y. District.

John D. Sullivan to speak in St. Louis, November 4:

The technical meeting arranged by the St. Louis District is to be a joint one with the St. Louis chapter of the American Society for Metals. John D. Sullivan, past president of the American Ceramic Society, and a former chairman of A.S.T.M. Committee C-8 on Refractories, will be the technical speaker. Mr. Sullivan is Chief Chemist and Assistant to Director, Battelle Memorial Institute, Columbus, Ohio.

Full details of this meeting will be sent to all A.S.T.M. members and others interested in the St. Louis District.

Meeting details are being arranged by the St. Louis District Chairman, Dr. J. C. Hostetter, and Secretary, J. M. Wendling, City of St. Louis, Municipal Testing Lab.

Aluminum—In Philadelphia, November 10:

The Philadelphia District is having "President's Night," on November 10 with President R. L. Templin speaking on the subject of "Aluminum."

This meeting is to be held at the

District Meetings

1948

October 13 Philadelphia
October 14 Washington (D. C.)
October 19 Chicago
October 26 New York
November 4 St. Louis
November 10 Philadelphia
November 16 Cleveland
November 19 New England
November 29 Pittsburgh
December 7 New York

1949

January 13 Philadelphia
February 3 New York
February 10 Philadelphia
March 22 Philadelphia
April 5 New York

Franklin Institute beginning promptly at 8 p.m. A cordial invitation is extended to everyone interested to attend. A dinner will precede the technical session.

President Templin to speak in Cleveland, November 16:

The subject of "Aluminum" will be discussed at the A.S.T.M. Cleveland District Meeting by President Richard L. Templin. This meeting is to be at the Cleveland Engineering Society Building, 2136 East 19th St.

More complete details of this meeting will be sent out to all A.S.T.M. members and others interested.

Philosophy of Specifications and Quality Control and Its Application to Industrial Problems—New England District, November 19:

The New England District is holding a meeting in Worcester, Mass., in line with the policy occasionally of holding their district affairs away from Boston,

and is joining with the New England Section of the Technical Association of the Pulp and Paper Industry, joint sponsors of this meeting.

District Chairman, V. J. Altieri, Eastern Gas and Fuel Associates, is very active in connection with New England District work, and R. H. Doughty, Fitchburg Paper Co., Fitchburg, Mass., has arranged the very interesting program planned for the meeting. This will consist of a paper on The Philosophy of Specifications by Wm. R. Willets and Dr. Lewis S. Reid, and a talk on Practical Quality Control by Dr. George E. Wadsworth, Associate Professor of Mathematics, Massachusetts Institute of Technology.

The meeting and dinner (reservations to Mr. Doughty) are to be in the Hotel Sheraton, Worcester, Mass.

Weather and Man—Pittsburgh, November 29:

Weather and the atmosphere is receiving increasing attention from the industrial aspects and the Pittsburgh District is having a meeting on a subject not only of popular interest but one of extreme importance from the industrial and technical viewpoint.

Dr. Hans H. Neuberger, Professor of Meteorology and Chief of the Division of Meteorology, Penn State College, who is the author of some forty-odd technical papers, including one textbook on "Weather and Man," will be the speaker, and promises to make the meeting one of great interest to all concerned.

New York District Meeting—December 1:

This District Meeting will be held in the Engineering Societies Building, Room 501. Decisions on speakers and other details have not been reached yet.

tarian businesslike conduct of our domestic production, business, and dealings with foreign nations seeking our assistance instead of wastefulness and giving up our whole economic standing is underscored.

It is time that we changed our dreams into active thinking and our aid and support to conservation of vital life, our natural resources.

Our Vital Life—Our Natural Resources

IN JULY Electrical Engineering there is an article by T. J. Russell, Application Engineer, Westinghouse Electric Corp., on the conservation of natural resources. A summary of this article follows:

It is imperative we appreciate that only a few hundred pounds of a mineral can decide the future of a nation.

We seem to have a good supply of coal, salt, potash, sulfur, iron ore, and phosphate rock. Such minerals as tin, nickel, quartz crystals, and platinum are scarce, as are tungsten, manganese, and mercury, and geological surveys show very little possibility of any new discoveries.

Our copper and zinc situation is a sad one.

Consequently, we must push geological research as well as efficient methods in mining and refining of our minerals.

We must educate the public to save every ounce of metal possible.

We must guard our forests and soil.

We must make sure that all our dealings with foreign governments are on a strictly business basis.

And we must lend our strength to preserve our national strength by doing everything in our power as engineers to preserve our resources. We must include in our "jobs ahead" the most urgent and important one of putting our support back of any movement or legislation that has anything to do with strengthening our nation by conserving our natural resources.

It is time we ceased being frustrated and chose the correct path; a humani-

Standardization Activities

(Continued from August BULLETIN)

Additional notes on the standardization activities of certain technical committees follow. These are a continuation of an extensive article which appeared in the August BULLETIN, pages 29 and 46.

COAL AND COKE (D-5)

In Committee D-5, Subcommittee I on Methods of Testing is conducting investigations leading to improvements and revision of the standard methods for determination of carbon, hydrogen, and nitrogen in coal and coke. It is proposed to revise these methods to take advantage of current developments in equipment and chemicals now available, especially for carbon and hydrogen determinations. Likewise, much experimental work has been published in recent years making use of chemicals to accelerate the method for determination of nitrogen. At present the standards contain no method for determination of mineral carbonates in coal so it is proposed to include such a method.

Subcommittee XX on Sampling and Fineness Test of Pulverized Coal is conducting investigations on methods of collecting representative samples of pulverized coal for size testing. This involves sampling the pulverized coal from a stream of coal and air inside of pipes between the pulverizer and the furnace. This is a difficult sampling procedure and considerable experimental work still needs to be done on this problem. Another active phase of the work of this subcommittee is the making of the fineness test and different methods are under investigation. These include both dry and wet sieving and the use of measurement of resistance to air flow through a column of pulverized coal under closely described conditions.

The committee has under consideration the possible standardization of methods for sampling and float-and-sink testing of coal in connection with the preparation of clean coal by removal of ash- and sulfur-forming impurities. Since such methods may be of principal interest as control methods at coal cleaning plants and not in the buying and selling of coal or coal cleaning equipment, it has not as yet been decided to undertake this work; but it is being held in abeyance pending the outcome of a similar project by the U. S. Bureau of Mines. This Bureau proposes to standardize float-and-sink testing methods for use in the laboratories of its own organization.

ENGINE ANTIFREEZES (D-15)

Committee D-15 on Engine Antifreezes and its subcommittees are actively studying the projects assigned to them. The subcommittee on freezing point determination is currently conducting a co-

operative test program to compare the accuracy and utility of three proposed test methods for determining the freezing point of antifreeze solutions. This group plans to hold its next meeting at the National Bureau of Standards in Washington, D. C., at the end of October. The three test methods will be available for inspection and test and, in addition, other projects under investigation at the Bureau will be on display.

A tentative performance specification for hydrometers has been prepared by the subcommittee on antifreeze field testers. This will be referred to the group for final clarification and then evaluated in a cooperative test program.

The subcommittee on physical properties and the subcommittee on chemical properties have assigned specific properties to individual members for investigation and the preparation of test methods based on information accumulated from the replies to questionnaires which have been received from members of committee D-15. Many of these proposed tentative methods will be ready for discussion at the next meeting of the respective subcommittees.

The subcommittee on simulated and actual service testing, through active study groups, is accumulating information on Recommended Practices for the Use of Antifreezes and Corrosion Inhibitors in the Engine Coolant System, and on test methods for corrosion and foaming. These study groups will circularize their findings to the subcommittee for comment. Working groups will then be formed to prepare the first draft of the Recommended Practices Manual and to evaluate proposed test methods.

Committee D-15 plans to hold its next meeting in Washington, D. C., coincident with the meeting of Subcommittee I. This will afford the members an excellent opportunity to acquaint themselves with the techniques used by the Bureau of Standards to test antifreezes. Other phases of the Bureau's varied research program, except those in restricted areas, will also be open for inspection.

QUALITY CONTROL OF MATERIALS (E-11)

The first fruits of the labors of Committee E-11 on Quality Control of Materials, organized in June, 1946, have materialized in the form of Tentative Recommended Practices for Designating Significant Places in Specified Limiting Values (E 29-48 T). This was accepted by the Society at the Annual Meeting and represents a revision of the Tentative Recommended Practices for Designation of Numerical Requirements and Standards (E 29-40 T).

It is expected that by the end of this year two other task groups of Committee E-11 will have completed their work. These committees are working on the

revision of the present A.S.T.M. Manual on Presentation of Data. This revision, which will constitute Sections 1, 2, and 3 of the new A.S.T.M. Manual on Quality Control of Materials, will contain revisions and additions to the old manual which should be of considerable interest to workers in the field of statistical quality control.

Several of the task groups are working on projects which, it is believed, are of general interest to the membership of the Society. One task group is now making a survey of the sampling plans used in A.S.T.M. standards; another is working on the problem of planning interlaboratory test programs; another on the sampling fluctuations of averages.

Committee E-11 sponsored a symposium on the Usefulness and Limitations of Samples at the Annual Meeting in Detroit on June 22. S. S. Wilks spoke on the "Usefulness and Limitation of Samples," Colonel L. E. Simon on "The Relative Variation of Material and Tests;" and G. R. Gause on "Amount of Inspection as a Function of Control of Quality."

Committee E-11 has assisted other committees of the Society in working out problems covering special phases of application of statistical quality control to A.S.T.M. problems. An extensive program covering work on statistical quality control problems relating to the activities of the Society has been planned for the coming year.

Staff Additions and Changes

WHILE notes of some of the activities of members of the Staff and information on Staff additions have occasionally appeared in the BULLETIN, no attempt has been made to keep members posted on all Staff matters. However, believing that many members will be interested, we may note more frequently some items concerning Staff activities.

On September 27, a change in routine occurred which is newsworthy—on that day the responsibility for receiving and distribution of mail was transferred to the Office Manager, J. H. Wolfe, Jr. What makes this seemingly prosaic statement of interest is the fact that since October, 1909 (yes, 1909), the Society's Treasurer, John K. Rittenhouse, known to a great many of the members and particularly to those who have been affiliated with the Society for a good many years, has handled details of mail distribution.

The volume of material received at Headquarters has continued to increase. When Uncle Sam's representative, the mailman, "staggered" into the building under his load three or four times a day, he leaves a large number of communications, manuscripts, packages from the printer, and dozens of other items on a variety of subjects and problems. A new automatic mail opener has been installed as part of our office equipment, and this is now in

effective use in expediting the opening and distribution of hundreds of pieces of mail that are received daily.

Mr. Rittenhouse, in addition to his duties as Treasurer in connection with the financial affairs of the Society, will continue to be responsible for handling orders for books and publications, and related items. The large number of orders received for the Book of A.S.T.M. Standards and the other technical books requires the constant and close attention of several staff members in Mr. Rittenhouse's department.

New Additions to the Staff:

In line with the recommendations of the Board of Directors' Committee on Membership, a young technically trained man has recently been added to the staff to intensify certain work along developmental and membership lines. Mr. John E. Bernados, a graduate of Muhlenberg College, and a resident of suburban Philadelphia, has joined the staff, reporting through the Assistant Secretary, R. J. Painter. Mr. Bernados won a scholarship to Muhlenberg where he majored in chemistry and he comes to us after two years of work in research with the Collins & Aikman Corp. In addition to handling membership and developmental contacts, he will be concerned with advertising development in the ASTM BULLETIN and aid staff members on other phases of the work.

From time to time secretarial and stenographic additions have been made to the staff, and the recent growth in this respect may be interesting. Three years ago, the staff comprised 34 employees; a year later, 41; a year ago 45; and today 48. This increase of about 40 per cent reflects a corresponding growth in the technical and publications work of A.S.T.M.

E. E. Thum, Metal Progress Editor, Comments on A.S.T.M. Work

IN HIS interesting column entitled "Critical Points" in the July, 1948 *Metal Progress*, the monthly magazine of the American Society for Metals, the editor, E. E. Thum, has some pertinent comments about A.S.T.M. work. A long-time member of A.S.T.M., Mr. Thum has contributed much to the advancement of the Society's work. It will be noted from the article below that he has some specific comments on the work of Committee B-2 on Non-Ferrous Metals and Alloys. This is not surprising for Mr. Thum was secretary of this group from 1928 to 1939 and from then until June, 1948, he served as chairman of the committee. The accompanying article should be of interest to all A.S.T.M. members, irrespective of their fields of interest.

Critical Points . . .

TO THE American Society for Testing Materials' meeting in Detroit and listened to some generous words concerning 20 years of officership on the Committee B-2 on Nonferrous Metals, and got to reminiscing on the changes time brings to institutions as well as men.

Shifts in Interest in Nonferrous Metals

Since the late great William Campbell of Columbia University resigned the chairmanship, the importance and diversity of specifications for the various cast and wrought copper alloys, the light metals, the die-cast metals, and the metal powders has grown so much that these portions of the work have been split off the old Committee B-2 and given a worthy independent status. More generally, the preponder-

ance of interest in the A.S.T.M. seems to have shifted to nonmetallic subjects, as judge by the number of subcommittee meetings at Detroit devoted to cement, paints, petroleum, rubber—there being more than three times as many as meetings considering steels, alloys, metallurgy, corrosion. This is a complete reversal of the proportion a generation ago. One now seldom hears the oft-repeated fallacy that specifications tend to fix the status of a material, to check progress, and to stifle improvement. How false this is—at least under the Society's procedure—is proved by the fact that two of the earliest specifications (for stranded copper conductor and slab zinc) were revised at this very meeting in Detroit. Zinc die castings are another notable example of continuous progress; minimum impact strengths are now more than double the maximum hoped for when the specification was first written. . . .

Finding the Facts Brings Agreement

As to formal procedure at the A.S.T.M. open meetings, a new member might say that they are affairs where decisions are railroaded through. He does not yet know how much work precedes these routine actions. Sometimes years are required to bring into common agreement two or three strong-minded groups of men, originally approaching a problem with diverse preconceptions and habits of thought stemming from long-established industrial customs. In every instance the first problem to be ascertained is "What are the facts?" Next: "What are the needs?" Once these are mutually understood, the prejudices melt away. Still though progress may appear at first slow such a project, this retiring chairman of Committee B-2 has never seen one installed where agreement between producers and consumers has been impossible.

Visual Aids and Methods in Standards

CONSIDERABLE emphasis is being placed on the use of visual aids in education and in a number of industrial activities as well, and it is of interest to note that visual methods have an important place in a number of A.S.T.M. standards.

Recently the Executive Secretary compiled a partial list of visual methods when he spoke at a meeting of Subcommittee IX on Mica, functioning under Committee D-9 on Electrical Insulating Materials. This subcommittee has been developing the possibility of establishing a series of color transparencies for the classification of mica. The Mica Fabricators' Association, at the request of Committee D-9, submitted seven samples of mica which could be considered as typical of the seven classes of

material given in methods D 351, and the committee hopes to make available for distribution transparencies of these materials which could be used as secondary standards.

Examples of standards using visual methods as noted in the Executive Secretary's talk follow:

Mica:

Standards for 3 qualities Air Inclusions in Mica (D 748).

Organic Impurities in Sand:

C 40—first example of color standard dating back 25 years.

Textiles:

Identification of Textile Fibers (D 276).
Defects in Woven Fabrics (D 123).
Cotton Yarn Appearance Standards (D 180).

Bacteria in Industrial Waters:

Iron Bacteria (D 932).

Sulfate-reducing Bacteria (D 993) illustrative of organic bacteria contributing to corrosion of iron requiring micrographic identification.

Paints:

In this field appearance standards are of considerable importance.

Rusting on Iron or Steel Surfaces (D 610).

Blistering (D 714).

Abrasion—Traffic Paint (D 821).

Chipping—Traffic Paint (D 913).

Motor Fuel:

Standard for Color of U. S. Army Motor Fuel—developed as War Emergency Method (D 976).

Metals:

Microstructure of Graphite in Gray Iron (A 247).

Micrographs (E 2).

Grain Size in Steels (E 19).

Inclusions in Steel (E 45).

Radiographic Standards for Steel Castings:

(a) 31 X-Ray Negatives.

(b) 31 Gamma Ray Negatives.

Proposed Method for Analyzing Fresh Mortar¹

A LONG-FELT need has existed in the building construction field for means of determining the actual basis and proportions of fresh mortar.

This proposed method is under jurisdiction of A.S.T.M. Committee C-12 on Mortars for Masonry. Published as information, October 1948.

This method covers a procedure for analysis of fresh mortar for its components—sand, lime, and cement.

Sampling:

If cylinders are to be made, a 1-lb. sample shall be taken. If only analysis is to be made, a 1-qt. sample will be sufficient. The sample shall be mixed thoroughly in a pan. Two samples weighing between 15 and 20 g. shall be placed into evaporating dishes for the moisture determination. Two 100-g. samples shall be weighed into the 200-mesh sieve (Section 3(a)). The remainder of the mortar shall be put into cardboard cylinders 2½ in. in diameter by 5 in. in height. The mortar shall be placed in two layers, each layer being tamped 15 times with the ¼-in. rod (Section 3(b)), and then leveled off with a glass plate.

Apparatus:

The apparatus shall consist of the following:

(a) Sieve.—A 200-mesh sieve approximately 3½ in. in diameter by 4 in. in height. This can be made by removing the bottom of a pint friction top can and covering on a 200-mesh bronze wire cloth.

(b) Rod.—A bullet-pointed rod ¼ in. in diameter by 10 in. in length.

Reagents:

(a) Bromoform-Carbon Tetrachloride mixture.—A bromoform-carbon tetrachloride mixture having a specific gravity between 2.60 and 2.70. Both the bromoform and tetrachloride can be U. S. P. grade. The approximate proportions are bromoform 82 per cent and carbon tetrachloride 18 per cent, by volume.

(b) Oleic Acid.

Procedure:

(a) Moisture Determination.—The moisture shall be determined either by drying to constant weight for approximately 2 hr. in an oven at 110°C. or by drying the sample with an infrared lamp placed approximately ½ in. above the top of the dish for about 15 min.

(b) Sand Content.—The two portions weighed into the sieves shall be washed three times by adding 100-ml. portions of water and stirring with a glass rod, and finally with the spray of a wash bottle. The sand then shall be dried to constant weight in an oven at 110°C. for approximately 1½ hr. or dried with an infrared lamp placed 2 in. above the top of the dish for about 15 min. After drying and sieving, the sand shall be sieved me-

chanically through a 200-mesh sieve to determine the amount of 200-mesh material remaining. If possible, a blank should be run on the original sand to make any corrections for the material passing a 200-mesh sieve.

(c) Cement Content (Lime and Cement Mortars).—The material washed through the 200-mesh sieve shall be centrifuged at about 1940 rpm. in 250-ml. sterilizing bottles and the clear supernatant liquid decanted. The residue in the bottles shall be dried, either to constant weight at 110°C. in an oven for 2 hr., or with an infrared lamp placed ½ in. above the top of the bottles in a horizontal position for about 15 min. The residue, which consists of the cement, lime, and any portion of the sand passing the 200-mesh sieve, shall be ground to a fine powder in a mortar with a pestle. Half of the residue shall be transferred to each of two 50-ml. centrifuge tubes (similar to paint-extractor tubes). One drop of oleic acid shall be added and then the bromoform-tetrachloride mixture, and the material stirred thoroughly. This mixture shall be centrifuged at about 1940 rpm. for a few minutes. The tube shall be removed from the centrifuge and the material on the top stirred; it then shall be put back into the centrifuge and the centrifuging continued at about 2050 rpm. until a clear separation results. The supernatant liquid, together with the material on the top, shall be decanted over a Whatman 41H, or equivalent, filter paper (rapid, hardened). The material remaining in the centrifuge tube and on the filter paper shall be dried to constant weight in an oven at 110°C. for about 1 hr., or under an infrared lamp placed about 1 in. above the tubes for about 15 min., and weighed.

(d) Lime.—The material retained on the filter paper may be weighed as lime or lime may be determined by difference.

(e) Masonry Cement.—If masonry cements have been used instead of a mixture of cement and lime, then the separation of the cement and lime is unnecessary and the sand determination is all that is required.

(f) Compression Tests.—The mortar in the cylinders shall be kept in a moist closet at 70°F. for 7 or 28 days as desired. The cardboard containers shall be stripped when the mortar has hardened sufficiently, which can be determined by scratching the surface with a fingernail. This should be a minimum of 72 hr.

Calculations:

6. The components of the mortar shall be calculated on a dry basis, as follows:

At this time the proposed method is published as information only. It is hoped that this will result in constructive criticisms and comments, which will be helpful to the committee in revising the method with the view of recommending it as a standard. Comments should be directed to A.S.T.M. Headquarters.

(a) Corrections for Sand Passing the 200-Mesh Sieve.—From a sieve test on the original sand and a sieve test on the sand retained on the 200-mesh sieve after washing out the matrix material, a correction shall be made both on the sand fraction and on the cement fraction, the sand being increased by this amount and the cement being decreased by this amount. The lime then shall be taken by difference. To convert this to volumetric proportions, each of the components shall be divided by its weight per cubic foot.

(b) Weights per Cubic Foot.—The weight per cubic foot for cement shall be taken as 94 lb., for hydrated lime as 50 lb., and for masonry cements as the weight given by the manufacturer. If the lime is to be calculated to lime putty, then a moisture determination on the putty shall be made. The percentage by weight of lime shall be corrected to lime putty and this value divided by the weight per cubic foot of lime putty. If the lime putty is not available, then 65 per cent can be taken as the amount of moisture and 80 lb. as the weight per cubic foot of lime putty.

(c) Sand.—If the sand is to be taken as damp-loose, the weight per cubic foot in this condition shall be determined and the percentage of moisture in the sand subtracted from this figure. If the sand is not available, then the sand can be assumed to weigh 80 lb. per cu. ft. damp-loose, and corrected for an average of 4 per cent moisture this would give a value of 76.8 lb. per cu. ft.

A.S.M. Sauveur Room

THE American Society for Metals on August 19 dedicated its Sauveur Memorial Room at the national offices in Cleveland. The procurement of material for this room including some of the effects of Dr. Sauveur and the funds to prepare the room and provide appropriate facilities had been initiated before the war. Dr. Sauveur was an active member of A.S.T.M. for many years and was among the first few members. In fact, his membership dated from 1896 which indicated his affiliation with the American Committee of the International Association for Testing Materials. A pioneering metallurgist and really the founder of the science of metallurgy, Dr. Sauveur's work both in the industrial field and as a teacher at Harvard has had an important imprint on this whole field.

Mattiello Memorial

MEMBERS of the Society who were friends and associates of the late Doctor J. J. Mattiello will be interested in the communication printed below from The New York Paint and Varnish Production Club concerning a memorial for Doctor Mattiello. He was a very active member of A.S.T.M., particularly on Committee D-1 on Paint, Varnish, Lacquer, and Related Products, and in 1946 he delivered the Edgar Marburg Lecture on "Protective Organic Coatings as Engineering Materials."

Many friends and admirers of the late Doctor Joseph J. Mattiello have been inquiring how they might participate in an undertaking to perpetuate the memory of one who labored so devotedly and effectively to promote the technological development of the paint and varnish industry. Plans recently announced by The New York Paint and Varnish Production Club now provide this opportunity.

The Club has planned to establish at the Polytechnic Institute of Brooklyn, a book collection, to be properly identified by a plaque, to be known as the Mattiello Memorial Collection. A substantial initial collection will be given a place in the Library of the Institute and will be augmented from year to year so that it may be kept as complete and up to date as possible. The use of this collection will be made available to those in the industry by the Institute.

The Club invites individuals, companies, or associations, who are interested, to make contributions. The facilities provided through this Memorial can be not only a permanent tribute to Doctor Mattiello, but a very useful reference library for members of the paint, varnish, lacquer, printing ink, and allied industries. The extent of its usefulness will depend largely on the comprehensiveness of the original collection and the funds available for additions.

The Club will welcome contributions of books pertaining directly or indirectly to paint and varnish technology and is particularly interested in rare, old, or out-of-print books, and also donations of funds, which will be dedicated to the purchase of additional volumes. Paint, Varnish and Lacquer Associations and Clubs are requested to bring this matter to the attention of their memberships.

Communications regarding contributions of books or funds should be made to Mattiello Memorial Committee, c/o The New York Paint and Varnish Production Club, 360 Furman St., Brooklyn 2, New York. Checks should be made payable to The New York Paint and Varnish Production Club. Acknowledgment will be made of all contributions.

MATTIELLO MEMORIAL COMMITTEE
ROBERT D. BONNEY, Chairman

"Fossils" Organized in Washington

MANY members of the society will be interested to note the organization in Washington of a "Fossils Club," which Dr. Harvey L. Curtis, long-time A.S.T.M. member, is President. Curtis was awarded an A.S.T.M. Honorary Membership at the 1948 Annual Meeting in June. In an interesting account of the organization of the "Fossils" which appeared in the Washington *Evening Star* of August 2, Dr. Curtis explained about the "Fossils," pointing out that there were a lot of "old boys" sitting around passing time, and it wasn't before he and a small circle of friends had grown into a group of over 60 "oldsters" who have joined together for social and service.

The membership requirements in "Fossils" are simple, namely, male and retired from life's work.

The "Fossils" are divided into groups according to interest, and there are many kinds of activities going on. The calendar for September showed five projects, three of which were motor tours and excursions with the monthly meeting covering "Civilization in Ancient Egypt and Its Debt to It," and another discussion group meeting on the subject "How Can Communism Be Prevented?" In early August, the baby of the "Fossils" was a young, 62-year-old retired contractor.

Dr. Curtis' home address is 6316 Larchmont St., Chevy Chase 15, Md. "Fossils" Secretary is Alex. McC. Ashby, 5 West Melrose St., Chevy Chase 15,



Dinner Group of Committee A-6 on Magnetic Properties at 1948 Annual Meeting—a testimonial to the retiring chairman Thomas Spangler who headed the Committee since 1925.

Standing, l. to r.: Eberly (Carpenter Steel); Dieterly (Armco); Taylor (Western Union); Zuschlag (Magnetic Analysis Corp.); Wiegel (Armour Research Foundation); Stoker (Carnegie-Illinois); G. W. Smith (Carnegie-Illinois); Getting, Allis-Chalmers; Luby (Empire Steel); Ashworth, Bell Telephone Laboratories; Bye, Simonds Saw and Steel; Rust, Armco; Gaalaas (Empire Steel); B. M. Smith (General Electric); Frey (Wheeling Steel); Bihlman (Wheeling Steel).

Speakers Table: Amey (Leeds and Northrup); Barton (Carnegie-Illinois); Sanford (National Bureau of Standards); Spooner (Westinghouse); Cole (Armco), Fahy (Consulting Engineer).

Left hand table, l. to r., starting lower left: Mitch (Indiana Steel); Beiler (Westinghouse); Horstman (Westinghouse); Carr (Westinghouse); Morris (Republic Steel); Adams (General Electric); Merrill (Niles Rolling Mill Co.); Maynard (Indiana Steel).

Right hand table, l. to r.: Lamson (General Radio); Witsberger (Penn. Transformer Co.); Feth (Follansbee Steel); Buck (Continental Steel); Hale (Allegheny Ludlum); Gaugler (Naval Ordnance Lab.); Field (General Radio); Dillinger (Western Electric).

Molybdenum: Steels, Irons, Alloys

THE varied applications of molybdenum as an alloying element are described in this book, which covers a wide range of materials from wrought to steels and from cast iron to non-ferrous alloys. Published in July, 1948, by the Climax Molybdenum Co., the book was edited by R. S. Archer, J. Z. Briggs, and W. I. Loeb, Jr. The major emphasis has been placed on the presentation of the fundamentals that must guide all engineers, designers, and metallurgists in their selection of the most suitable materials for a given application.

In the past, many books have been limited to the presentation of uncrossed data on specific compositions, each of which has been treated as a self-sufficient entity. Yet, as every practical man knows, many of these are interchangeable within certain limits. In the present work, an attempt has been made to show fields of similarity and dissimilarity of various materials and to indicate some of the factors that may affect the choice of the most economical material for a specific purpose.

The scope of the book is illustrated by the main section headings: Technical Aspects of Molybdenum, Fundamental Aspects of Heat Treatment on Microstructure, Addition of Molybdenum, Wrought Alloy Engineering Steels, Wrought Corrosion Resistant Steels, Wrought Steels for Elevated Temperature Service, Tool Steels, Metal Castings, Cast Iron, Special Purpose Non-ferrous Alloys.

Considerable recent information is included, not only on the more prominent developments, such as the gas turbine steels and alloys; but also on the work that has served to clarify the factors affecting the service life of the lower alloy steels. The references to current literature

are adequate to facilitate further reading by anyone who desires more detailed data.

A valuable addition is the compilation of much rather obscure, hard-to-find information on some of the specialty applications, such as: exhaust valves elevated temperature springs, ferritic gas turbine steels, high permeability alloys, contact materials, grid wires, and prosthetic alloys. The appendices include data on standard compositions of American, British, and French engineering steels, working stresses from the Boiler Code, conversion tables, and the physical properties of metallic molybdenum. The book has 392 pages and over 270 figures and tables. For further information address the Climax Molybdenum Co., 500 Fifth Ave., New York 18.

Concrete Waterproofing

THIS little book by L. E. Hunter is packed with information regarding the materials and practices used to make concrete structures waterproof. British in origin, it is concerned chiefly with the methods developed in Great Britain. Many are different from those used in this country, but the presentation of foreign methods makes the book all the more interesting. The author has drawn on our own National Bureau of Standards for results of tests on surface and integral waterproofings for concrete, but most of his sources are British.

There is a survey of the various types of waterproofing compounds and surface waterproofings. The author evidently has more faith in integral waterproofing for concrete than most American authorities, but he presents some good reasons for his stand. He is keenly aware, however, that the best of materials will fail to pro-

duce waterproof structures unless used with proper construction practices. His treatment of the problem of preventing leaks at the points where penetration generally occurs is comprehensive and thorough. The application of mastic asphalt on both concrete and brick masonry is covered, as is the use of cement mortar coatings (rendering is the British term). There is a good description of cement gun applications for waterproofing and concrete reconstruction work.

Some of the practices recommended are controversial. Most American readers will be startled to find that asphalt is recommended for waterproof or damp-proof courses and as a roofing, without fabric or felt reinforcements. The recommendations for cutoffs through parapet walls and the use of spandrel beam flashing will be objected to by many. Apparently the British do not worry about the much-discussed theory that masonry parapet walls have to be free to breathe. Coverings for the top and back of parapets are illustrated, and the Building Research Station (England) is quoted as recommending a damp-proof course under the coping, with a cement mortar coating on one face of the parapet.

Probably the most valuable feature of this book is the wealth of drawings showing the construction of joints in concrete and details of critical points in waterproofing treatments. Very few designers or builders have more than a superficial knowledge of this problem, and the failure to handle such details competently is a common cause of leaks. A perusal of the practices developed across the water as illustrated in this book should be profitable to those in this field of construction. Copies may be obtained from Pitman Publishing Corp., New York, N. Y., or Chicago, Ill., at \$2.50.

C. C. CONNOR



Incheon Meeting of Committee D-11 on Rubber and Rubber-Like Materials, held during the A.S.T.M. Annual Meeting in Detroit. Honored Guests were Past-President Arthur W. Carpenter, Long-time Secretary of Committee D-11, and Mrs. Carpenter. Mr. Carpenter was tendered best wishes and congratulations and thanks for his efforts, and Mrs. Carpenter was presented with a goodly number of "cartwheels" as a wedding gift from the committee.

An Introduction to Color

"An Introduction to Color" by Ralph M. Evans is far more profound than its title would suggest. It is better described by the subtitle—"A detailed study of color—its physical, psychophysical, and psychological aspects." These three aspects are introduced in the first chapter and are reemphasized and interrelated over the remaining twenty chapters.

This book contains so much material that it will be welcomed by teachers as a text for both beginning and advanced students. Among workers in color, it will stimulate discussion and promote a better understanding of the subject because of the manner in which older concepts are treated and for the new concepts that are introduced, particularly in the three chapters dealing with perception.

In the paint and textile fields, experienced color matchers will find considerable theoretical and practical information in the chapters on The Measurement of Color, Transparent Colorant Mixtures, and Paints and Pigments for teaching apprentices the regular and anomalous behavior of colorants, which otherwise is learned only through years of experience. Systems of color organization and specification are given careful treatment and the discussion includes their application and limitations in the chapter on The Specification of Color. Perhaps the most remarkable feature of this book is the way in which the perception of objects and scenes—that is, how these appear to us in everyday life—is related to the conditions under which we see such objects. Discussions of this will interest members of the new A.S.T.M. Committee E-12 on Appearance.

The physical aspects of color are illustrated by an almost countless number of spectrophotometric curves. The author emphasizes the usefulness of this material through the simplicity with which many phenomena are explained. Psychophysical information is illustrated mostly by the

ICI chromaticity plot. Illustrations in both color and black and white demonstrate visual illusions relating to color, size, depth, and texture.

The layout, typography, and choice of illustrations show that much consideration has been given to the design of the book. The printing, particularly the color plates, is very fine.

While a few of the author's opinions are controversial, I believe it to be the best work in which science and art are blended since Von Bezold's "The Theory of Color" published in 1876, and think everyone who is interested in color or has color problems will find Mr. Evans' book of real value. Comprising 350 pages, with 15 color plates, this 1948 book was published by John Wiley and Sons, 440 Fourth Ave., New York. The price is \$6.

WALTER C. GRANVILLE

[EDITOR'S NOTE.—Mr. Granville is Assistant Director, Department of Design, and Head, Color Standards Department, Container Corporation of America, Chicago, Ill. He is active in the work of a number of A.S.T.M. committees including D-1 on Paint, Varnish, Lacquer, and Related Products—he is Secretary of Subcommittee X on Optical Properties; is one of the A.S.T.M. representatives on the Inter-Society Color Council, and is a member of the new Committee E-12 on Appearance Standards.]

Forest Products Research Guide

FOREST products industries are in that category of industries which were built on a long tradition of apprenticeships and the practice of arts. It is usually found that these industries are slow in accepting the tools and findings of research. Thus it has only been in very recent years that research has come into its own in this field,

but the volume of research today is indicative of the importance now placed on

The National Lumber Manufacturers Association has published this year a third edition of the "Forest Products Research Guide," compiled by the Committee on Products and Research. This recognizes the large volume of research on forest products and the need for a guide and reference to the many projects.

One of the principal reasons for publishing this Guide is to aid in the coordination of forest products research and help prevent unnecessary duplication of research activities. It provides a reference to general and specific kinds of research completed or under way in organizations conducting forest products research.

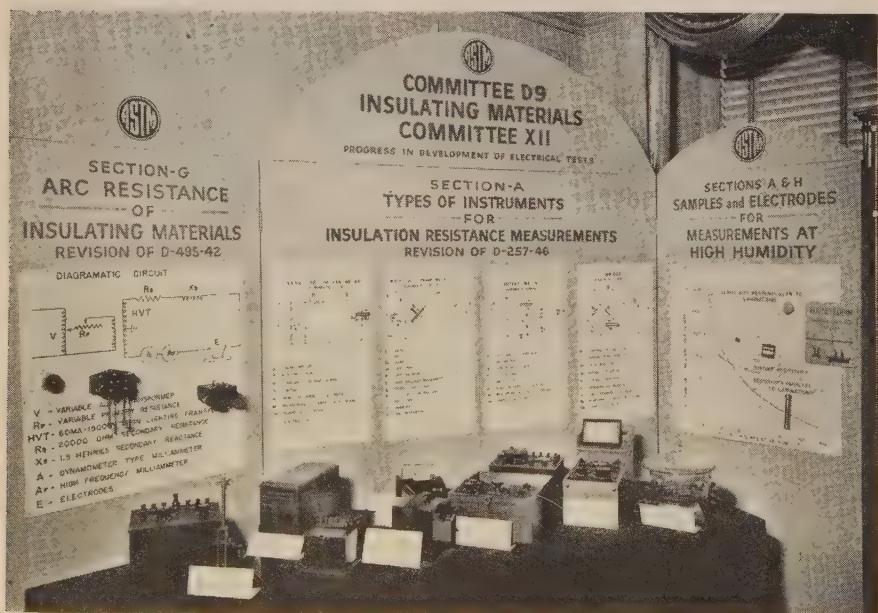
The third edition of the "Forest Products Research Guide" is superior to previous editions for several reasons. Perhaps the greatest contribution is that reference is now made to many research activities which were secret and confidential at the time the previous editions were published. This edition contains at least double the number of research classifications, as well as more than twice as many references as contained in the second edition. It has also been improved by indexing to provide easy reference to classification of research and kinds of research undertaken by each organization.

This Guide may be obtained from headquarters of the National Lumber Manufacturers Association, Washington 6, D. C., and is priced at \$5.

Strength of Houses

ONE of the latest in an extensive series of Building Materials Structures Reports published by National Bureau of Standards, is BMS 10 on "Strength of Houses." This particular report is one of the most comprehensive in the series, as well as being of great current value and timely interest to those in the housing field. Quoting from the foreword, "Strength of houses in the past has been made adequate by patterning them after those which have withstood the test of service conditions. Architects and builders of small structures have followed closely, traditional methods handed down from the craftsmen of medieval England. From these traditions, cities have crystallized building codes now enforced under the police power of the community."

"The trend for the immediate future seems to indicate houses so constructed to contribute in greater measure to the welfare of the occupants by bringing more of the out-of-doors into the house. Windows to give more sunlight and air; stimulating vistas of garden, trees, flowing water; larger rooms and movable partitions; and walls, floors, and roofs fabricated from plastics and from



The Display Sponsored by Committee D-9 on Electrical Insulating Materials in the A.S.T.M. Exhibit in Detroit. Included in the display were instruments, equipment, and informative panels covering phases of the work of the committee.

and magnesium alloys are some of improvements anticipated.

“Any research failed to disclose methods for determining the strength of present-day houses and little respect that could be applied to design for the future. This report attempts to apply engineering methods to design of houses for strength. Wind data for wind, snow, and loads have been reviewed and computing methods developed for computing loads.”

It is interesting to note that the work of the A.M. Committee E-6 on Methods of Building Construction has been closely allied with the activities of the National Bureau of Standards. H. L. Rose, co-author of BMS 109, is chairman of Subcommittee I on Panels for Building Construction of Committee E-6.

A Directory of Public Administration Organizations

THE Public Administration Clearing House, 1313 E. 60th St., Chicago, Ill., has recently issued its sixth edition of a Directory of Public Administration Organizations. It is designed to help public officials and others concerned with governmental problems to sources of useful information and to identify organizations which impinge upon or affect public administration. All of the organizations listed can be placed in one of the following categories: Organizations for, Public Officials and Administrators, Professional and Technical Societies, and Citizen Organizations. This gives one an idea of the extent of the book; there are 2381 organizations covered, of which 565 are national, 1700 state, and the balance regional or Canadian. The same style used in previous editions has been followed, providing name and address of the organization with chief staff officer listed, information on membership, finances, and extent of the organization, a short statement of activities, and a list of affiliations and publications. The book is of real help and service to those who have contacts with the fields covered. Comprising some 230 pages, 6 by 9½ in., copies of the book can be obtained from the Administration Clearing House at \$3.50 per copy.

Scientific and Technical Societies and Institutions of the United States and Canada

THIS handbook, of which the present edition is the fifth, is issued by the National Research Council of the National Academy of Sciences, to provide a directory of those societies, associations, and similar organizations in the natural sciences and related fields that contribute to the advancement of knowledge through meetings, publications, and other sources. The current 370-page book covers 1468 organizations in the United States and Canada. For each group

covered, following the title and address there is given the name of the president and of the chief staff officer, with a short history, statement of purpose, information on membership, meetings, research funds, medals, etc. Data on publications are also given. There is a detailed subject classification of activities, purposes, and research funds covering both the United States and Canada. Copies of this publication, 6½ by 9½ in., can be obtained from the Publication Office, National Research Council, Washington, D. C., at \$5 each.

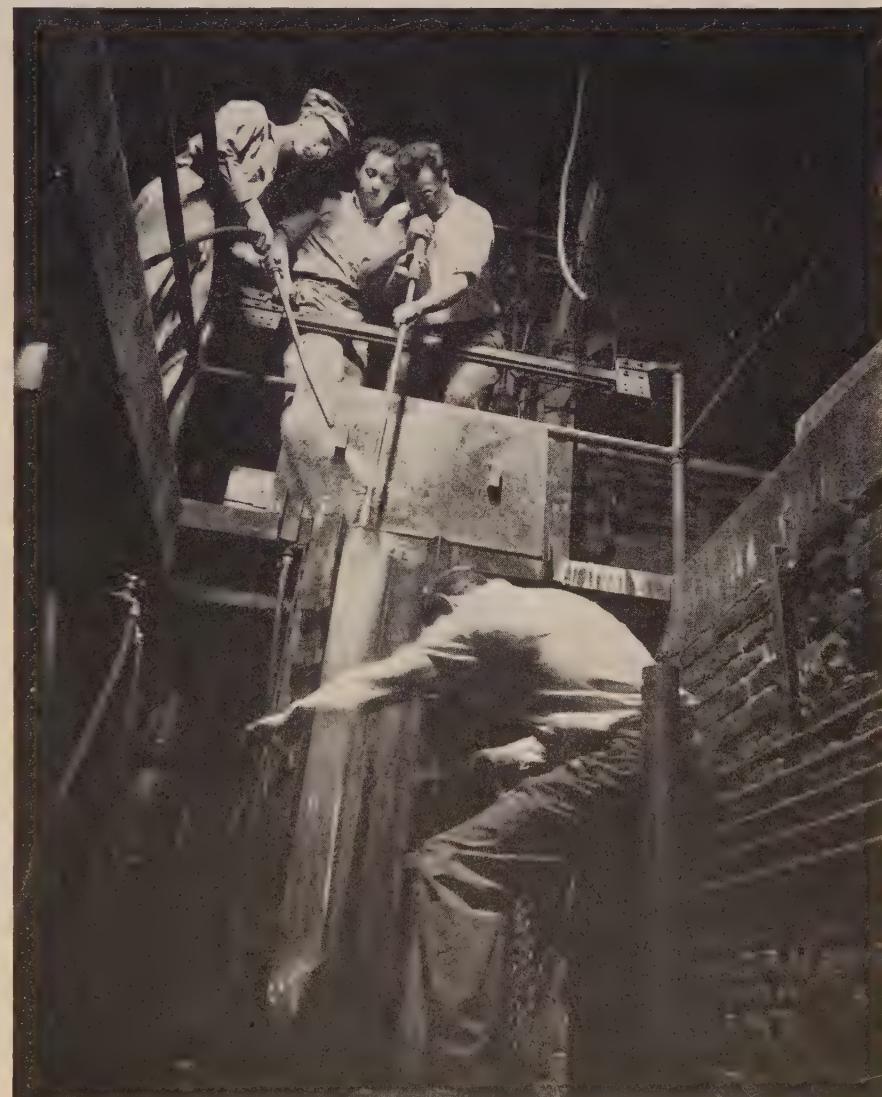
Design Manual for Airport Pavements

THIS new manual issued by the Wire Reinforcement Institute, Inc., National Press Bldg., Washington 4, D. C., closely follows the current requirements of the U. S. Civil Aeronautics Administration, thus making it of special value for use in the design of airport landing facilities to be constructed under the Federal-Aid Airport Act. It is not intended to re-

place the judgment of the designer, or engineer, in his knowledge of local needs, materials, and methods. Its purpose is to place in his hands, in concise form, the data covering many features of design established by previous research and experience of others in the field; plus the considered opinions and mature judgment of the U. S. Civil Aeronautics Administration officials. Tables, graphs, charts, and up-to-date formulas are included to permit a sound, practical and economical design of landing facilities—an essential feature in the development of an airport or aviation base.

The Technical Service Division of the Wire Reinforcement Institute, Inc., has prepared this manual in recognition of the long-standing need to bring together the data necessary for adequate and economical design.

Included among the pertinent information presented are two A.S.T.M. specifications: one covering Welded Steel Wire Fabric (185), the other, Cold-Drawn Steel Wire for Concrete Reinforcement, (A-82).



“Blowing a Large Cylinder”

Second prize-winning photograph, General Section, General Interest Group, in the Sixth A.S.T.M. Photographic Exhibit, by John Kalinich, Corning Glass Works.

Mechanics Colloquium in Chicago

SEVERAL members of the Society are scheduled to participate in the Mechanics Colloquium held under the auspices of the Illinois Institute of Technology in Chicago. A schedule of the meetings, topics and speakers follows:

October 6, 1948—"Interpretation of Service Fractures" by R. E. Peterson, Westinghouse Research Laboratories, East Pittsburgh, Pa.

November 3, 1948—"Latest Developments in Jet Propulsion" by J. T. Rettaliata, Illinois Institute of Technology.

December 1, 1948—"An Applied Mathematician's View of the Problem of Elastic Stability" by J. J. Stoker, Institute for Mathematics and Mechanics, New York University.

January 5, 1949—"Evaluation of Brittle Coating as a Tool for Experimental Stress Analysis" by A. J. Durelli, Armour Research Foundation of Illinois Institute of Technology.

February 2, 1949—"Some Phenomena of Non-Steady Flow" by W. Spannake, David Taylor Model Basin, U. S. Navy, Washington, D. C.

March 2, 1949—"Bridges and Aerodynamics" by D. B. Steinman, Consulting Engineer, Robinson and Steinman, New York City.

April 6, 1949—"Aircraft Flutter Problems" by N. C. Myklestad, University of Illinois, Urbana, Ill.

May 4, 1949—"Stress, Strain-Rate and Strain Relations in the Plastic Range, Including an Analysis of Finite Homogeneous Strains" by A. Nadai, Consulting Engineer, Westinghouse Research Laboratories, East Pittsburgh, Pa.

All meetings except the first will be held on the Illinois Tech campus, 3300 South Federal St. The October 6 meeting was conducted at Northwestern University's Technological Institute, Evanston, Ill. The Colloquium is open without charge to the public. Lectures are scheduled for 8 p.m. and are preceded by a dinner at 6:30 p.m.

Those who wish further details of each session can have their name placed on a mailing list by contacting R. L. Janes, Assistant Professor of Mechanics at Illinois Tech., and Colloquium Secretary.

A.S.T.M. in the "Ethyl" News

THE September *Ethyl News*, this house organ being published by the Ethyl Corporation, 405 Lexington Ave., New York 17, N. Y., includes two items referring to A.S.T.M. that are of interest. In the article describing Ethyl's first big customer which was Standard Oil Co. of Indiana it is of interest to point out that as a result of studies made by the Standard Oil personnel including Dr. William M. Burton, first President of Indiana, and Dr. R. E. Wilson, then Assistant Director of Research, and now the company's Board Chairman, that details of the contract were

worked out. The details were handled by the late Thomas Midgley for Ethyl and Dr. Wilson. Quoting from the article "this they did while en route together to Atlantic City to attend an A.S.T.M. meeting. The contract was signed a few months later."

There is reference to the Society also in an interesting article "Gasoline Quality Abroad" by Errol J. Gay, consultant to several companies on problems relating to engines and their fuels and lubricants. He refers to the octane values in a large number of European and South American countries, all of which were based on the A.S.T.M. Motor Method. This is an excellent example of one of the great values of a standardized method, such as an A.S.T.M. standard, giving a true basis of reference so that different quality materials can be directly related. The octane values in South America range from 64 to a high of 80 for a premium fuel; in Africa the quality is practically uniform at about 70 octane number leaded. Mr. Gay expresses the consensus of a number of observers that any notable improvement in overseas motor fuel quality can probably not be expected until 1952 at the earliest.

New Portland Cement Association Research Center Under Construction

CONSTRUCTION is now under way on the new two-million-dollar research and development laboratory of the Portland Cement Association located at Skokie, Ill., fifteen miles northwest of Chicago. The new laboratory group consists of two buildings joined by a covered walkway and occupying more than 98,000 sq. ft. of floor space. This will be more than three times the floor space of the present laboratories built in 1926 and will contain more than 25 specialized laboratories, including rooms capable of duplicating conditions of extreme cold or tropic heat. A 1,000,000-lb. compression machine will feature the many items of new equipment to be installed.

Participating in the ceremonies on June 30, marking the placing of the first concrete, were Frank T. Sheets, President of the P.C.A., Dr. A. Allan Bates, Vice-President for research and development, and W. A. Wecker, S. W. Storey, and W. C. Russell, Directors of the Association. Charles E. Aspdin, great-great-grandson of the Joseph Aspdin who was granted a patent 124 years ago for the manufacture of the material called portland cement, had the honor of placing the first concrete in the new structure.

Dr. Bates, in his remarks concluding the ceremony, stressed the value of developments achieved in the present laboratory and that the completion of these new buildings "will put an effective tool in our hands for continued accomplishment to the same end."

Congress on Bridge and Structural Engineering—Preliminary Publication Received

THE preliminary publication of the large number of papers presented at the Third Congress sponsored by the International Association for Bridge and Structural Engineering in Belgium in September, 1948, is a 700-page book with typographic style and binding identical with earlier editions. The publication is arranged under the following headings:

- I. Assembling devices and structures in steel structures
- II. Developments in building structures in concrete and masonry
- III. Developments in long span bridges
- IV. Slabs and various curved structures in reinforced concrete
- V. Analysis of safety and efficiency dynamic forces

Under Part I are papers on the progress of welding technique, the design of connections, and strength and stability of thin-walled structures. Papers in Part II deal with progress realized in the quality of concrete, new types of reinforcement and notable structures executed before 1936. Part III covers contributions on the theory of suspension and long-span bridges. Part IV includes a general review on the evolution, importance of, and necessity for further development in the use of mushroom slabs, continuous slabs, curved walls and shells in reinforced concrete structural work; also additional papers on continuous slabs, and strength and stability of disks and shells in curved and cord form in concrete. The twelve contributions in Part V deal with the conception of safety and such aspects and problems as determination of curve of dispersion of test pieces of steel and samples of masonry, inelastic behavior, dynamic influence of moving loads on girders, differential vibration of vibrations in load-bearing structures by moving loads, damped oscillations of frame girders, etc.

Each paper is published in three languages—French, German, or English—by the original author, but summaries of all papers and reports are given in these languages.

The General Secretaries of I.A.B.S.E. are: Dr. sc. techn. F. Schmid and Dr. sc. math. P. Lardy, both Professors at the Swiss Federal Institute of Technology, Zurich.



On this and the next page are photographs of some technical committee officers. Others will appear in subsequent Bulletins.

Committee D-18 Solicits Help In Revision of Procedures for Soil Testing

THE compilation entitled "Procedures for Soil Testing" prepared by Committee D-18 on Soils for Engineering Purposes and published by the Society in September, 1944, has proved a popular and valuable book. It was felt desirable to bring the book up to date and to broaden its scope. For this purpose, a special subcommittee has been formed. Careful consideration was given to choosing the members of this committee in order that all fields of interest in soil testing should be represented. It is felt that the following selection of members for this committee represents the activities in various fields of soil testing:

D. Catton (Chairman), Portland Cement Association.
G. Gold Allen, Public Roads Administration.
D. Finney, Kansas State Highway Commission.
H. S. Housel, University of Michigan.
W. Johnson, Highway Research Board.
W. Klinger, Standard Oil Co. of New Jersey.

Members of Committee D-2 on Petroleum Products and Lubricants: I. to r.; C. L. Sizzen, Chairman; L. C. Beard, First Vice-Chairman; W. T. Gunn, Secretary; G. Maag, Second Vice-Chairman.

P. E. McCoy, American Bitumuls Co.
P. F. Phelan, Koppers, Inc.
Rockwell Smith, Association of American Railroads.
W. T. Spencer, Indiana State Highway Commission.
J. H. Swanberg, Minnesota State Highway Commission.
D. M. Burmister, Columbia University.
W. G. Holtz, U. S. Bureau of Reclamation.

The main objective of the new publication is to include not only the soil testing procedures for which tentatives or standards of the Society have been written, but also any other soil testing procedures which may have been used successfully to determine physical and mechanical properties of soils. Soil laboratories under both state and Federal control have developed procedures for determining many soil properties which

Officers of Committee A-1 on Steel: 1. to r.; N. L. Mochel, Chairman; T. G. Stitt, Vice-Chairman; H. B. Oatley, Vice-Chairman; H. C. Larson, Secretary.

should be reviewed for consideration. It is the belief of the membership of Committee D-18 that the publication of such procedures would be very helpful to the advancement of knowledge and practice in soil testing for engineering purposes.

It is, therefore, the hope that everyone interested in soil testing who may have developed or who has knowledge of a procedure which has been successfully used, will communicate with the Chairman of this committee, M. D. Catton, Portland Cement Association, 33 W. Grand Ave., Chicago, 10, Ill. It would be of tremendous help to the committee if suggested procedures were submitted in the A.S.T.M. Standard Form beginning with Scope, Apparatus, etc., and continuing with the details of the tests.

It is the earnest hope of Committee D-18 and the especial aim of the members of the subcommittee that the new booklet cover every phase of soil testing for engineering purposes. For this reason, the help of any interested person or group is earnestly requested.



the A.S.T.M. Committee on Membership

1916 Race St., Philadelphia 3, Pa.

gentlemen:

Please send me information on membership in A.S.T.M. and include a membership application blank

Signed _____

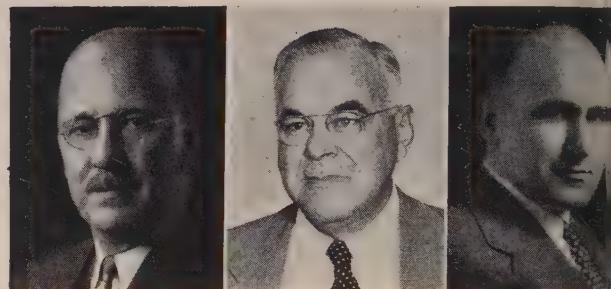
Address _____



Officers of Committee D-13 on T
Materials: 1. to r.: H. J. Ball, Chair-
G. E. Hopkins, First Vice Chair-
Frederic Bonnet, Second Vice-Chair-
W. H. Whitcomb, Secretary.

Testing Refractories for the Foundry

AN INTERESTING paper was presented at the 1948 Annual Meeting of the American Foundrymen's Association on the subject of "Testing Refractories for the Foundry" by Mr. S. M. Swain, Director of Research, North American Refractories Co. The important part played by the many A.S.T.M. standards in the refractories field is brought out by the many references made in this article. It deals with the careful planning, selection of objectives, justification of costs and safety factors for a testing program; together with detailed recommendations for sampling, critical discussions and brief descriptions of test methods covering the many physical and chemical properties required. Three general types of testing programs are discussed and recommendations are made for large and small foundries.



Officers of Committee A-10 on Iron-
Chromium, Iron-Chromium-Nickel and
Related Alloys (lower left); 1. to r.;
Jerome Strauss, Chairman; L. L. Wyman,
Vice-Chairman; H. D. Newell, Secretary.

Officers of Committee B-6 on Die-
Metals and Alloys: 1. to r.; J. R. T.
send, Chairman; J. C. Fox, Vice-Chair-
man; G. L. Werley, Secretary.



To the A.S.T.M. Committee on Membership, 1916 Race St., Philadelphia 3, Pa.

Gentlemen:

Please send information on membership to the company or individual indicated below.

This company (or individual) is interested in the following subjects: (indicate field of activity, the
petroleum, steel, non-ferrous, etc., etc..)

Date _____

Signed _____

Address _____

New Sustaining Members

SEVERAL organizations have recently joined sustaining memberships in the Society, in some cases these being effected by transfers from the company member class. A list of recent new sustaining members follows:

BROUGHS ADDING MACHINE CO. (1948), Detroit, Mich.; C. C. Dahl, Chief Research Engineer.

CALIFORNIA RESEARCH CORP. (1948), San Francisco, Calif.; H. G. Vesper, president.

THE COLORADO FUEL AND IRON CORP. (1940), Pueblo, Colo.; J. Hart Beece, Chief Metallurgist.

GENERAL PETROLEUM CORP. (1917), Los Angeles, Calif.; Gale L. Adams, Manager, Laboratories Dept.

THE PERMANENTE METALS CORP. (1948), Spokane, Wash.; Paul P. Zeigler, Director, Div. of Metallurgical Research.

The Glenn L. Martin Co. (1940), Baltimore, Md.; H. C. Engel, Chief of Engineering Laboratories.

It will be noted from the dates of membership appearing after the companies that one organization, The Colorado Fuel and Iron Corp., has been a member since 1900, while the others carry more recent dates. When a company transfers to the sustaining class it retains the membership year when it first became affiliated with the Society.

The A.S.T.M. Membership Committee and the Board are appreciative of this evidence of the interest of these organizations in the Society. The sustaining membership class provides an opportunity for companies which inherently benefit from the A.S.T.M. work to a greater extent than does an individual, to underwrite the work to a degree more commensurate with the

value received than is the case with a company membership. Sustaining members pay annual dues of \$150. They have the same privileges as do companies of having the name listed in the Year Book—in fact, sustaining members are listed in a special portion of the Year Book; they can designate different technically qualified individuals to serve on the diverse committees to which the company may be elected; and sustaining members can receive a copy of every A.S.T.M. book that is issued. This includes the Book of A.S.T.M. Standards (there is no extra charge for a complete set) and the numerous other special compilations and symposiums. Information on some of the advantages of sustaining membership will be furnished gladly to any companies which are interested.

The number of sustaining numbers is now 215.

Members to September 21, 1948

The following 106 members were added from July 12, 1948, to September 21, 1948, making the total membership 6475.

Names are arranged alphabetically—company members first, then individuals.

Chicago District

BOIS CLAY PRODUCTS CO., Howard F. West, Research Engineer, 214 Barber Bldg., Joliet, Ill.

BOIS, C. J., Owner and Director, DuBois Research Labs., California and Daniel St., Danville, Ill.

BEDINGER, J. P., Partner, Soil Testing Services, 730 Madison St., Evanston, Ill. For mail: 644 N. Elmwood Ave., Oak Park, Ill. [J]*

BREITER, HARRY WALTER, Technical Director, Vascoloy-Ramet Corp., 800 S. Market St., Waukegan, Ill.

BUCK, W. E., Engineer of Tests, The Gulf, Mobile and Ohio Railroad Co., Bloomingdale, Ill.

ZELST, THEODORE W., Civil Engineer, Soil Testing Services, 730 Madison St., Evanston, Ill. [J]

Cleveland District

GENERAL FIREPROOFING CO., THE, Glenn T. Purley, Chief Products Engineer, Youngstown, Ohio.

HAZIC TILE CO., THE, David J. Barbour, Research Director, Zanesville, Ohio.

KETT, ROBERT A., Technical Service, Inney & Smith Co., 424 Ohio Bldg., Akron 8, Ohio.

LEIN, HENRY, Laboratory Division Chief, Engineering Dept., Perfection Stove Co., 309 Platt Ave., Cleveland 4, Ohio. For mail: 1542 Hillcrest Rd., Cleveland 18, Ohio.

MANNIS, A. R., Sales Manager, United States Quarry Tile Co., 730 Renkert Bldg., Canton, Ohio.

Detroit District

BROUGHS ADDING MACHINE CO., C. C. Dahl, Chief Research Engineer, 6071 Second Ave., Detroit 32, Mich. [S]*

ERROL J., Technical Consultant on Petroleum and Automotive Industries, 303 Fisher Bldg., Detroit 2, Mich.

LOWAX PRODUCTS DIVISION, UNION CARBIDE AND CARBON CORP., D. H. Seeds,

Plant Engineer, Biddle Ave., Wyandotte, Mich.

KAUER, JOSEPH A., Engineer, Technical Service, Huron Portland Cement Co., 13th Floor, Ford Bldg., 601 Griswold St., Detroit 26, Mich.

SPLEET, STERLING J., Division Engineer, Standard Oil Co. (Indiana), 1011 Fourth St., Detroit 31, Mich.

New England District

SUPERIOR ELECTRIC CO., THE, William P. Carpenter, Chief Engineer, 83 Laurel St., Bristol, Conn.

ASHLEY, SAMUEL E. Q., Analytical Chemist, Transformer and Allied Products Division, General Electric Co., Pittsfield Works, 100 Woodlawn Ave., Pittsfield, Mass.

BECHARD, ROBERT WILLIAM, Chemist (Plastics), Southbridge Finishing Co., Inc., Southbridge, Mass. For mail: R. F. D. 2, Box 74, Lowell, Mass. [J]

FLAGG, FREDERICK F., Consulting Metallurgist, Judson L. Thomson Mfg. Co., Waltham 54, Mass.

SAGENDORPH, GEORGE A., President, Penn Metal Co., Inc., 40 Central St., Boston 9, Mass.

New York District

KENT CLIFF LABORATORIES, Edward H. Enberg, Jr., Director of Standards, Box 696, Peekskill, N. Y.

PLASTICRETE CORP., Philip Paoella, Vice-President, Box A, Hamden 14, Conn.

BEE, JOHN M., Vice-President, Macalaster Bicknell Company of Connecticut, Inc., 181 Henry St., New Haven 11, Conn.

BURTON, LAURENCE V., Executive Director, Packaging Inst., Inc., 342 Madison Ave., New York 17, N. Y.

DIXON, JOHN B., Member of Technical Staff, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

GREINER, LEONARD E., Proprietor, Gootlieb Greiner Co., 50 Dey St., New York 7, N. Y.

JACKSON, WHARTON, Industrial Engineer, Georgia Kaolin Co., 433 N. Broad St., Elizabeth 3, N. J.

McGINN, EARL P., Industrial Editor, Paper Trade Journal, 15 W. Forty-seventh St., New York 19, N. Y. For mail: 9 Mountainview Rd., Verona, N. J.

PALADINO, FRANCIS J., Plant Pathologist, Webster Research Laboratory, 85 Central Ave., White Plains, N. Y. For mail: 42-49 147th St., Flushing, L. I., N. Y.

RATICHEK, A. J., Vice-President, Bishop

Gutta-Percha Co., 420 E. Twenty-fifth St., New York 10, N. Y.

SHERWOOD, ROBERT F., President, United Feldspar and Minerals Corp., 10 E. Fortieth St., New York 16, N. Y.

SMITH, HILLARD A., Plant Manager, Richmond Radiator Co., Box 111, Metuchen, N. J.

SULLIVAN, WILLIAM L., Chemical Engineer, Westinghouse Electric Corp., Lamp Division, Bloomfield, N. J.

WIDMAIER, WILLIAM, Vacuum Tube Engineer, Federal Telephone and Radio Corp., 100 Kingsland Rd., Clifton, N. J. For mail: 168 Bowden Rd., Cedar Grove, N. J.

WILLIAMS, GRIFFITH, JR., Supervisor of Methods, Revere Copper and Brass Incorporated, Rome, N. Y. For mail: 280 Main St., New York Mills, N. Y.

WITSCHEN, WILLIAM G., Chief Quality Control Engineer, Refrigeration Division, Noma Electric Corp., 46 Oliver St., Newark, N. J. For mail: 2039 W. Broad St., Westfield, N. J.

ZENORINI, HENRY J., Buyer, Z. B. Yarn Mills, Inc., 600 Fifty-fifth St., West New York, N. J.

Northern California District

CALIFORNIA ASSOCIATED CONCRETE PIPE MANUFACTURERS, H. W. CHUTTER, President, Box 152, Fresno 7, Calif.

CALIFORNIA RESEARCH CORP., H. G. Vesper, President, 200 Bush St., San Francisco 4, Calif. [S]

STANFORD RESEARCH INST., J. E. Hobson, Director, Stanford, Calif.

MCCONNELL, ED S., Manager, Rod, Wire and Cable, Permanente Products Co., 1924 Broadway, Oakland 12, Calif.

WATTS, VILAS E., Research Consultant, Box 1094, 725 Loma Verde Ave., Palo Alto, Calif.

Ohio Valley District (In Course of Organization)

CAROTHERS, RICHARD B., Partner, H. C. Spinks Clay Co., 1103 First National Bank Bldg., Cincinnati, Ohio.

HOWE, E. E., Manager, Ceramic Division, Lustron Corp., 4200 E. Fifth Ave., Columbus 16, Ohio.

INDIANA UNIVERSITY, DIVISION OF GEOLOGY, Owen Hall, Bloomington, Ind.

RHODES, FRASER B., Ceramist, The John Douglas Co., Cincinnati 16, Ohio.

Philadelphia District

SCHOLLER BROTHERS, INC., E. C. Dreby, Director of Research, Collins and Westmoreland Sts., Philadelphia 34, Pa.

ANDERSON, ROBERT E., Manager, Robertson Manufacturing Co., Morrisville, Pa.
 DERMODY, WILLIAM J., Chief Chemist, Stokes Molded Products, Trenton, N. J. For mail: Wilfred Ave., Washington Crossing, R. D., Titusville, N. J.
 HANS, LOIS V., Chemist, Hercules Powder Co., Experiment Station, Wilmington, Del. For mail: 1010 Delaware Ave., Wilmington, Del.
 KILLMER, JOHN K., Metallurgical Engineer, Bethlehem Steel Co., Inc., Bethlehem, Pa.
 MYLER, ALAN B., Technical Representative, Sun Oil Co., 1608 Walnut St., Philadelphia 3, Pa.
 PHELPS, GILBERT W., Technical Director, United Clay Mines Corp., 101 Oakland St., Trenton 6, N. J.
 STUART, HERBERT W., Director of Quality Control, U. S. Pipe and Foundry Co., Burlington, N. J.
 VENZIE, EDMUND F., President, The Venzie Corp., 2238 N. Twenty-seventh St., Philadelphia 32, Pa.
 WILLIAMS, C. T., Metallurgist, Frazer Farm Equipment Division, Graham-Paige Motors Corp., York, Pa.

Pittsburgh District

SHENANGO POTTERY CO., E. P. McNamara, New Castle, Pa.
 UNIVERSAL SANITARY MANUFACTURING CO., J. R. Beam, Technical Director, Box 960, New Castle, Pa.
 GEFFNER, Joseph, Joseph Geffner Co., R. F. D. Route No. 1, Weirton, W. Va.
 HEPPLEWHITE, J. W., Chief Ceramic Engineer, The Edwin M. Knowles China Co., Newell, W. Va.
 HOWELL, JOHN, Metallurgical Supervisor, Jones & Laughlin Steel Corp., Aliquippa, Beaver Co., Pa.
 JONES, W. H., Mechanical Engineer, Duquesne Light Co., 435 Sixth Ave., Pittsburgh 19, Pa.
 WELLS, ARTHUR A., Vice-President and General Superintendent, Homer Laughlin China Co., Newell, W. Va.

Southern California District

GENERAL PETROLEUM CORP., Gale L. Adams, Manager, Laboratories Dept., 108 W. Second St., Los Angeles 12, Calif. [S]
 STATHAM LABORATORIES, INC., Gifford White, Associate Director, 9328 Santa Monica Blvd., Beverly Hills, Calif.
 UNITED CONCRETE PIPE CORP., H. A. Weigand, Engineer, Box 425, Baldwin Park, Calif.
 BRENNAN, FRANK P., Manager, Los Angeles Branch, United States Testing Co., Inc., 1415 Park Ave., Hoboken, N. J. For mail: 1236 Maple Ave., Los Angeles 15, Calif.

PERSONALS • • •

News items concerning the activities of our members will be welcomed for inclusion in this column.

R. L. Beach—"Rex" to his many friends and associates in the Society—has retired as of September 1 from active work with the General Electric Co., Schenectady, N.Y. He has been a very active member of Committee D-6 on Paper and Paper Products since its organization in 1937, and also an active participant in the work of Committee D-10 on Shipping Containers, having been Vice-Chairman of the latter from 1945 to 1948, and contributing to a number of phases of this work, most notably perhaps in the work on "Definitions of Terms," of which subcommittee he was secretary.

HOLLINGER, E. R., Technical Director, The Sherwin-Williams Company of California, 3170 E. Pico Blvd., Los Angeles 23, Calif.

Washington (D. C.) District

STOREY, ALVIN B., Superintendent, Textile, Celanese Corporation of America, Cumberland, Md.
 WITT, RICHARD P., Chief, Physical Testing Lab., Aberdeen Proving Ground, Ordnance Department, Aberdeen Proving Ground, Md. For mail: Emmorton Rd., Bel Air, Md.
 YOUNG, L. O., Chemical Engineer, The Davison Chemical Corp., Curtis Bay Works, Baltimore 26, Md.

Western New York and Ontario District

GENERAL ELECTRIC CO., HOUSEHOLD REFRIGERATOR DIVISION, W. L. Maucher, Director, Works Lab., 2901 East Lake Rd., Erie, Pa.
 HENTHORN, DAVID W., Spectroscopist, Vacuum Corporation of America, Aluminum Div., Niagara Falls, N. Y. For mail: 316 S. Third St., Ann Arbor, Mich. [J]
 McIVER, JOHN K., Metallurgist, Commercial Controls Corp., 1 Leighton Ave., Rochester 1, N. Y. For mail: 233 Valley Rd., Rochester 10, N. Y.
 NANDA, J. N., Technical Education Scheme, Government of India, Council of Scientific Research, New Delhi, India. For mail: 118 Cook St., Ithaca, N. Y.
 NELSON, EDWARD J., Laboratory Director, Rochester Gas and Electric Corp., 89 East Ave., Rochester 4, N. Y.
 SCHRAMM, EDWARD, Director of Research, Onondaga Pottery Co., Syracuse 4, N. Y. For mail: 1858 W. Fayette St., Syracuse 8, N. Y.

U. S. and Possessions

ASBESTONE CORP., J. H. Schiele, Chief Chemist, Box 5257-B, New Orleans 15, La.
 COLORADO FUEL AND IRON CORP., THE, J. Hart Reece, Chief Metallurgist, Pueblo, Colo. [S]
 NATIONAL SUPPLY CO., THE, HOUSTON PLANT DIVISION, C. R. Neilon, Chief Engineer Box 2616, Houston 1, Tex.
 PERMANENTE METALS CORP., THE, Paul P. Zeigler, Director, Division of Metallurgical Research, Box 1451, Spokane 6, Wash. [S]
 BALL, JOHN S., Refinery Engineer, U. S. Bureau of Mines, Box 621, Laramie, Wyo.
 BROWN, KENNETH R., Owner, Brown Engineering Co., 322-334 KP Bldg., Des Moines 9, Iowa.
 CARNEGIE LIBRARY, Mariam N. Craddock, Chief, Acquisition and Processing Div., 3rd and Robinson, Oklahoma City 2, Okla.

CAZORT, W. S., Jr., Chief Chemist, C. I. Martin and Co., 1215 Dumble St., Houston 3, Tex.

ECKHARDT, OWEN S., Research Chemist, Southern Naval Stores, Inc., Columbia, Miss. For mail: c/o Reasor-Hill Co., Jacksonville, Ark.

HIGGINSON, ELMO C., Materials Engineer, U. S. Bureau of Reclamation, Bldg. 1, Denver Federal Center, Denver, Colo.

LOWE, A. KIRK, Purchasing and Product Engineer, Young Iron Works, 2900 Ave., South, Seattle 4, Wash.

MARMO, E. J., Associate Professor of Engineering Mechanics, University of Nebraska, Lincoln, Nebr. For 1835 S. Twenty-fifth St., Lincoln, Neb.
 McCCLAMMY, HERBERT, Consulting Engineer, Reynolds, Smith & Hills, Box 4817, sonville 1, Fla.

MCLEOD, NEIL R., System Engineer, Phoenix Union High Schools and J. College District, 3010 N. Eleventh Street, Phoenix, Ariz.

MIELZEN, RICHARD C., Head, Petrography Lab., U. S. Bureau of Reclamation, Denver Federal Center, Denver, Colo.

MITCHELL, LANE, Director, School of Ceramic Engineering, Georgia Institute of Technology, Atlanta, Ga.

POWELL, WILLIAM LLEWELLYN, Partner, Powell & Powell, Engineers, 501 Third Bldg., Dallas 1, Tex.

RUSSELL, JOSEPH E., President, Texas Vents and Chemicals Co., 8501 Market Street, Houston 15, Tex.

SARRETT, HOMER J., JR., Refining Engineer, Betty Asphalt Co., Waterloo, Ark.

SWEET, HAROLD S., Assistant Professor, University of Wyoming, College of Engineering, Laramie, Wyo.

UNITED STATES MARINE CORPS, MARINE CORPS EQUIPMENT BOARD, Marine Corps Schools, Quantico, Va.

WHALEY, N. P., Owner, Whaley Engine Co., 118 W. Cameron, Tulsa, Okla.

Other than U. S. Possessions

HELLENIC COTTON BOARD, Churchill Street, Athens, Greece.

INSTITUTO DEL HIERRO, Y DEL ACERO, Villanueva 15, Madrid, Spain.

JUNTA NACIONAL DOS PRODUTOS PECUARIOS, Department of Economy Ministry, Castilho, N.º 20, Lisbon, Portugal.

SCHOEN, M. J., Director, N. V. Pieter Schon and Zoon, Ltd., Zaandam, Netherlands.

SOUTH AFRICAN RAILWAYS, Chief Civil Engineer (Research), Railway Headquarters, Johannesburg, South Africa.

WOLOCHOW, DAVID, Head, Codes and Specifications Section, Building Research Station, National Research Council, Ottawa, Ont., Canada.

* [J] denotes Junior Member.

† [S] denotes Sustaining Member.

and Alloys. He was a member of numerous subcommittees and contributed a great deal from his knowledge and experience in furthering many of the Society's activities. His record with his company is notable one, his affiliation dating back to 1900. He is a member of numerous technical organizations and groups in Trenton. The best wishes of his many friends and associates in the Society are extended to Mr. Bellis as he relinquishes his active industrial and Society contacts.

Paul O. Blackmore has been transferred from the Cincinnati plant of Interchemical Corp. to head the Basic Development Laboratories for the Finishes Division, Newark, N.J.

F. B. Brennan, Manager, Los Angeles Testing House branch of the United States Testing Co., and a new member of the Society, is the Chairman of the Pacific Coast Section of The American Association of Textile Chemists and Colorists.

This section having recently been established a charter. Mr. Brennan was given responsibility by his company of establishing a new Pacific Coast laboratory.

Charles O. Burgess, for 25 years head of the Nickel and Gray Iron Research Laboratory of Union Carbide & Carbon Co., Niagara Falls, N. Y., has been appointed Technical Director of the Gray Iron Foundry Society, Inc., Cleveland. Mr. Burgess has been Secretary of A.S.T.M. Committee A-3 on Cast Iron since 1940 and was Chairman of Committee A-7 on Malleable Castings from 1944 to 1946.

George F. Comstock, for many years Metallurgist of the Titanium Alloy Co., Niagara Falls, N. Y., has been appointed Assistant Director of Research of the Titanium Co.'s laboratories.

Horace Couliette, of Industrial Research Institute of the University of Chattanooga, has been appointed Technical Director of the Institute.

Warren E. Davis, Associate Professor of Engineering at the University of California, Berkeley, has been appointed Director of the University's new statewide Institute of Transportation and Traffic Engineering. Prof. Davis, with other members of the faculty, has been organizing a teaching and research program.

Mr. Davis has been appointed Manager of the newly created Development and Research Department of Continental Oil Co., Tulsa, Okla. He has been supervisor of technical services of the company's manufacturing department.

H. Deppeler, Chief Engineer of the Metal & Thermit Corp., has been granted leave of absence to open a consulting office at 36 W. 40th St., New York City, to devote his entire attention to development of his own business as a Consulting Engineer. He will retain his connection with the Metal & Thermit Corp. Consultant for that organization as well. Deppeler is one of the founders of the American Welding Society and was its first president, his experience in the welding field extending over a 40-year period starting in the early days in the acetylene field and later covering every type of arc welding.

Leicester G. Fisher, President of Fisher Scientific Co. and Eimer & Amend, and former Award, honored the achievements of the recipient of the award, Dr. Nell Furman of Princeton University, through the usual medal but by an etching made and appropriately inscribed to the purpose. In addition to the etching there was a cash prize of \$1,000. This award was made at the Fall Meeting of the American Chemical Society.

Francis C. Frary, Director of Research, Aluminum Company of America, New Kensington, Pa., has been elected to receive the Gold Medal of the American Society for Metals for 1948, awarded for outstanding metallurgical knowledge and versatility in the application of science to the metal industry, as well as exceptional ability in the diagnosis and solution of diversified metallurgical problems.

B. J. Fraser, Assistant Manager, Development & Research Div., The Interna-

tional Nickel Co., New York City, has been elected to serve as First Vice-President of The American Welding Society for 1948-1949.

After serving in the Conservation Division of the War Production Board, in the Navy Department and at Chefford Master Mfg. Co. for the past six years, **J. Ralph Fritz** has returned to Hotpoint, Inc., Chicago, where he will be engaged in development work.

Elizabeth Genger has severed connection with the Westinghouse Electric Corp. Home Economics Institute, Mansfield, Ohio, and is now with *Woman's Home Companion*, New York City.

Ray P. Dinsmore, Vice-President in Charge of Research for the Goodyear Tire & Rubber Co., Akron, Ohio, is the recipient of the Colwyn Gold Medal for 1947, presented to him during his recent visit to England by the Institution of the Rubber Industry. The award was made in recognition of his work in synthetic rubber research, development, and application.

C. E. Hartwig, Director of Research for Swan-Finch Oil Corp. Newark, N. J., is pleased to announce the promotion of **W. C. Bryant** to the position of Chief Research Chemist. For the past two years Mr. Bryant has been a group leader in the Research Department. Previously he had spent eight years in the Production Division as a Control and Chief Chemist.

Wendell Frederick Hess, Associate Professor in Metallurgical Engineering and Head of Welding Lab., Rensselaer Polytechnic Institute, Troy, N. Y., is the 1948 recipient of the Wetherill Medal of The Franklin Institute, awarded "in consideration of his outstanding contributions to the art and science of welding, notably in the field of electric resistance welding."

John C. Hintermaier has accepted a position as Supt. of Development, Cluett, Peabody and Co., Inc., Troy, N. Y. He was formerly Chief Chemist, Vanity Fair Mills, Inc., Reading, Pa.

Chester A. Hogentogler has retired as Chairman of the Highway Research Board's Department of Soils Investigations. He has been succeeded by Harold Allen, Senior Materials Engineer of the U. S. Public Roads Administration. Mr. Hogentogler also is retiring from his position as Principal Highway Engineer of the P.R.A. An outstanding authority in his field, Mr. Hogentogler was Chairman of A.S.T.M. Committee D-18 on Soils for a number of years.

Eugene J. Houdry, of **Houdry Process Corp.**, Philadelphia, is to receive the 1948 Potts Medal from The Franklin Institute. This medal is awarded "in consideration of his leadership in the development of catalytic cracking of petroleum that bears his name, utilizing known basic chemical and physical facts" and will be presented October 20.

President Wilfred Sykes, of the **Inland Steel Co.**, Chicago, Sustaining Members of the Society, has been elected to receive the 1948 Award of Merit by the Chicago Technical Societies Council. This award is presented annually to the Chicagoland citizen "who has made the most important

contributions toward cultivation of greater appreciation by the public of the part which technology, engineering, and science have played in human welfare."

Arnold Ivan Johnson is now Engineering Aide, U. S. Geological Survey, Water Resources Branch, Lincoln, Nebr. He was previously Junior Engineer, Nebraska Department of Roads and Irrigation.

Harry Jumper, Chief Engineer of Consolidated Rock Products Co., Los Angeles, Calif., has been elected Mayor of Azusa. He has also been elected to a two-year term on the City Council. He formerly served as Mayor for some months in 1942 prior to entering the military service, and has previously served two four-year terms as Councilman.

Key Company, East St. Louis, Ill., recently promoted **Fred B. Riggan**, formerly Chief Metallurgist, to the position of Foundry Manager and General Superintendent. Arnold Czechowicz was appointed Assistant Foundry Superintendent, and Robert Jacoby was advanced to the position of Chief Metallurgist.

Joseph A. Kies, formerly Senior Metallurgist, Oak Ridge National Lab., Div. of Carbide & Carbon Chemicals Corp., Oak Ridge, Tenn., is now at the Naval Research Lab., Washington, D. C., in the Ballistics Section, Mechanics Division.

Ernst Loebell has joined the staff of the Hanchett Mfg. Co., Big Rapids, Mich., as Design Engineer. He was formerly Specification and Process Engineer, Gibson Refrigerator Co., Greenville, Mich.

John H. Longbottom, of Gadsden, Ala., is now in the U. S. Army Service as a Chemist at the Army Chemical Center in Maryland.

M. W. Loving, Consulting Engineer and Concrete Technologist, widely known throughout the concrete products and cement industries, has moved his office from Chicago to Glenview, Ill. Mr. Loving was a former secretary of the American Concrete Pipe Association. He has been active in various A.S.T.M. technical committees for many years, and served as Secretary of Committee C-13 on Concrete Pipe from 1933 to 1946.

G. E. F. Lundell, for many years Head, Division of Chemistry, National Bureau of Standards, and a noted authority on many phases of analytical chemistry, retired as of September 1. A Past-President of A.S.T.M., Dr. Lundell has a long record of service in the Society's activities, notably in its work on chemical analysis of metals. He was interested in this work many years before Committee E-3 on Chemical Analysis of Metals was organized, this having taken place in 1935. He has been chairman of this group since that time. He is the author of a large number of technical papers and reports and of several authoritative books.

Marcel A. Martin has accepted a position as Physicist, American Optical Co., Buffalo, N. Y. He was formerly Physicist, Physique et Industrie, Paris, France.

Robert F. Mehl, Director of the Metals Research Laboratory of Carnegie Institute of Technology, Pittsburgh, has recently been named Chairman of the National Research Council Committee on Ship

Steel. One of the responsibilities of this group is to advise on a research program in connection with investigation of failures of ship steel, particularly plates. During the summer Dr. Mehl delivered the Hattfield Memorial Lecture in London, England.

Dalton G. Miller, Materials Engineer, Public Roads Administration, located at the University of Minnesota, was awarded the John Deere Medal of the American Society of Agricultural Engineers for "distinguished achievement in the application of science and art to the soil." The award was made on the basis of Mr. Miller's work on drainage tile and on sulfate resisting concrete for such uses. Mr. Miller is a member of Committees C-1 on Cement, C-4 on Clay Pipe, and C-15 on Manufactured Masonry Units.

Carl W. Muhlenbruch, formerly Assistant Professor of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa., has joined the staff of the Northwestern Technological Institute, Evanston, Ill.

Herbert P. Pearson, formerly Manager, Soilpak Div., Service Engineering Co., Summit, N. J., is now Manager, Soilpak Corp., New York City.

Merle Randall has left the Stuart Oxygen Co., Berkeley, Calif., and is now a member of the firm of Randall & Sons at 2512 Etna St., Berkeley.

Two new appointments have recently been made to the Technical Board of the Society of Automotive Engineers. One of the appointees, Harold T. Youngren, is

Vice-President of Engineering, Ford Motor Co., and the other, **W. D. Reese**, is Manager of Engineering, Motor Truck Division, International Harvester Co. Mr. Reese is a member of Technical Committee A of A.S.T.M. Committee D-2 on Petroleum Products.

Frank H. Sanders, formerly Chemical Engineer with the Houdry Process Corp., Linwood, Pa., is now associated in a similar capacity with the Arabian American Oil Co., Dhahran, Saudi, Arabia.

Samuel R. Scholes recently resigned as Dean of the New York State College of Ceramics at Alfred University. For many years recognized as one of the outstanding authorities on glass technology in the country, Dr. Scholes is resuming his former position as head of the Department of Glass Technology, and has been named Associate Dean in charge of curricula and teaching. He has been an active member of Committee C-14 on Glass and Glass Products for many years, serving as Secretary from 1944 to 1948.

One of the St. Louis newspapers recently had a picture and note about A.S.T.M. Past-President **Herman von Schrenk**. The paper indicated that it is believed he is the only St. Louisian among the some 170 living persons who have been listed in all editions of "Who's Who in America." One of the country's leading consultants on timber, he is an Honorary Member of A.S.T.M. He recently retired as Chairman of Committee D-7 on Wood, which he had headed since its organization

in 1904. Those who greeted him at Annual Meeting in June in Detroit were not impressed by any noticeable lack of typical von Schrenk pep and enthusiasm even though he is under doctor's orders "take it easy."

Ralph A. Sherman of the Battelle Memorial Institute has been elected Director of The American Society of Mechanical Engineers.

Foster D. Snell, President of Foster Snell, Inc., and General Chairman of the fall meeting of the American Oil Chemists' Society, to be held in New York City November 15-17, inclusive, has recently appointed **H. W. Vahlteich**, Vice-President in Charge of Research and Quality Control, Best Foods, Inc., Bayonne, N. J., as Vice-Chairman of the meeting. Dr. Snell is active in various phases of the work of A.S.T.M. including Committee D-12 on Soaps and Other Detergents.

Philip Sporn, President, American Gas and Electric Service Corp., and **D. L. Steinman**, Consulting Engineer, New York City, both Columbia University graduates, were awarded medals by their alma mater at commencement exercises in June. Sporn's citation commended his "alertness to current trends, and extraordinary much-respected appraisals of power development," while Mr. Steinman's cited his standard "always to place service before profit, the honor and standing of the profession before personal advantage, the public welfare above all other considerations."

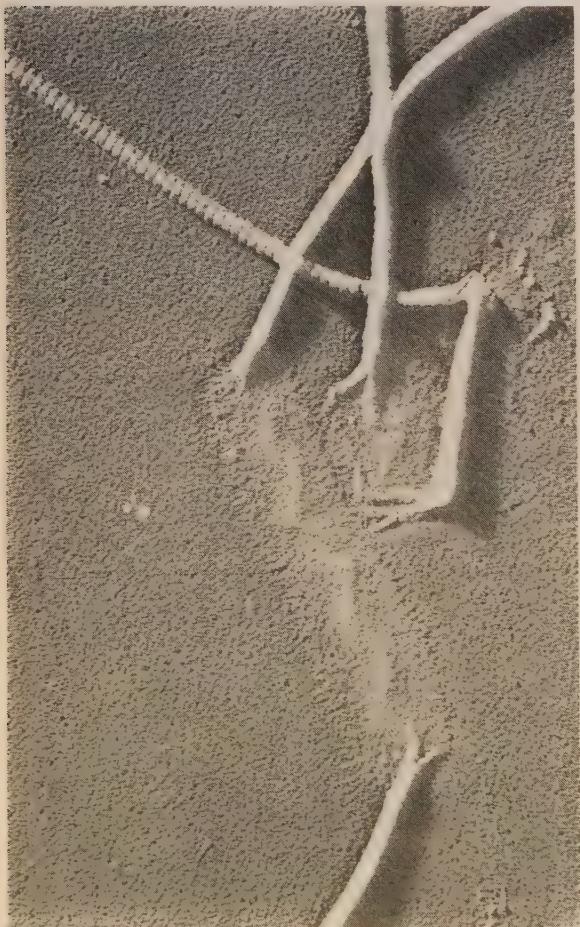
Syracuse University announces formation of a Department of Materials Engineering as a division of its College of Applied Science. This Department, under the direction of **Dr. B. J. Lazan**, occupies new building on the new Engineering Campus of the University. Besides teaching undergraduate and graduate courses in the field of metallurgy, materials testing, and applied mechanics this department is now conducting research projects for the Army Air Forces, Office of Naval Research, and industrial concerns in the field of dynamic testing of materials, fatigue, damping, and creep. Its facilities include laboratories for metallurgical and metallographic preparation, testing, and inspection, static testing, fatigue and vibration testing, X-ray radiographic testing up to 1,000,000 volts, dynamic creep testing, damping capacity testing, and a well-equipped experimental machine shop.

Lewis A. Tomes has been transferred from the National Bureau of Standards to the District of Columbia Highway Department, Washington, D. C., where he will serve as Junior Inspector.

Stanley D. Triplett is now associated with the Brockway Glass Co., Brockway, Pa. He was formerly Materials Engineer, Pennsylvania Department of Highways, Harrisburg.

J. W. Westwater, formerly on the faculty of the University of Delaware, Newark, Del., has been named Assistant Professor of Chemical Engineering, University of Illinois, Urbana.

An honorary degree of Doctor of Engineering has been conferred by the



"Collagen Fibers"

First prize-winning photograph, Photomicrographic Section, Electron Micrograph Group (shadow casting techniques) in the Sixth A.S.T.M. Photographic Exhibit, by M. C. Botty, American Cyanamid Research Laboratory. Collagen fibers from cowhide after partial disintegration in warm water, showing partial gelatinization, 26,700 \times . This specimen was uranium shadowed to enhance observation of structure.

University of Detroit on Alfred Holmes White, Professor Emeritus of Chemical Engineering at the University of Michigan. Dr. White joined the Michigan faculty as an Instructor in 1897 and became Professor of Chemical Engineering in 1907. In 1943 he was made Professor Emeritus.

W. P. Wiltsee has retired as Chief Engineer of the Norfolk & Western Railway Co. Mr. Wiltsee was with the railroad for 7 years, having gone into its service when the old Cincinnati, Portsmouth and Virginia Railroad by which he was then employed was purchased by the Norfolk & Western.

Clarence W. Winchell, who has resigned as Chief of the New Jersey Bureau of Standards, has joined the staff of the United States Testing Co., Inc., Hoboken.

Charles E. Wuerpel, recently Concrete Engineer with the Inter-American Construction Corp., Buenos Aires, Argentina, is now with the U. S. Department of the Army Corps of Engineers, Washington D. C.

Errata

Frank E. Lobaugh, Manager of the Lumnite Division, Universal Atlas Cement Co., New York City, has advised that our note concerning his succession to certain of the responsibilities of Joshua L. Miner listed in our August ASTM BULLETIN was incorrect. Mr. Lobaugh succeeded Mr. Miner as Manager of the Lumnite Division and not as Vice-President of the Company.

Society Appointments

Announcement is made of the following appointments:

T. A. Boyd, General Motors Corp., Chairman; G. R. Gohn, Bell Telephone Laboratories, Inc., and W. C. Voss, Massachusetts Institute of Technology, on the Marburg Lecture Committee.

H. S. Vassar, Retired, Public Service Electric and Gas Co., Chairman; E. L. Hollady, Army Service Forces, Ordnance Dept., and C. E. Wuerpel, Department of the Army Corps of Engineers, on the Charles B. Dudley Medal Committee.

H. L. Whittemore, Mechanical Engineer, on the R. L. Templin Award Committee (with R. E. Peterson, Westinghouse Electric Corp., Chairman, and M. F. Sayre, Union College, continuing).

A. W. Tracy, The American Brass Co., on the Sam Tour Award Committee (with C. D. Hocker, Union College, Chairman, and L. W. Hopkins, American Chain and Cable Co., continuing).

P. S. OLMSTEAD, Bell Telephone Laboratories, Inc., on the Administrative Committee on Ultimate Consumer Goods.

P. S. Reid, Metropolitan Life Insurance Co., and R. C. Adams, U. S. Naval Engineering Experiment Station, on the Administrative Committee on Papers and Publications.

L. H. Winkler, Bethlehem Steel Co., Inc., on Committee E-1 on Methods of Testing, to succeed L. H. Fry, deceased.

A. E. MILLER, Sinclair Refining Co., and DEAN HARVEY, Consultant on Materials, as members of Committee E-8 on Nomenclature and Definitions; Mr. Miller to succeed L. H. Fry, deceased, and Mr. Harvey succeeding G. B. WATERHOUSE, Massachusetts Institute of Technology, resigned.

C. T. HATCHER, Consolidated Edison Co. of New York, Inc., as A.S.T.M. representative on ASA Sectional Committee C 59 on Electrical Insulating Materials, to succeed R. W. ORR, RCA Victor Division of Radio Corp. of America.

F. S. EATON, Research and Design Institute, Inc., on ASA Sectional Committee A 91 on Building Granite, to succeed D. W. KESSLER, National Bureau of Standards.

R. L. SANFORD, National Bureau of Standards, on ASA Sectional Committee C 42 on Definitions of Electrical Terms.

M. R. PAUL, Frederic H. Rahr, Inc., on ASA Sectional Committee Z 58 on Standardization of Optics.

M. K. HOLMES, Owens-Illinois Glass Co., on ASA Sectional Committee C 29 on Insulators for Electric Power Lines, to succeed U. E. BOWES, Owens-Illinois Glass Co., resigned.

W. J. McCOY, Lehigh Portland Cement Co., on ASA Sectional Committee A 42 on Specifications for Plastering, to succeed J. C. PEARSON, deceased.

C. T. EVANS, Jr., Elliott Co., and HERMAN WEISBERG, Public Service Electric and Gas Co., as members of the Joint A.S.T.M.-A.S.M.E. Committee on Effect of Temperature on the Properties of Metals.

NECROLOGY

CLARENCE W. BALKE, Research Director, Division I, Fansteel Metallurgical Corp., North Chicago, Ill. (July 8, 1948). Member since 1944. Member of Committee B-9 on Metal Powders and Metal Powder Products, and an outstanding authority in this field.

W. H. BROADHURST, Consulting Chemist, Highway Materials, Brooklyn, N. Y. (February, 1948). Member since 1899.

M. M. CLARK, District Manager, Climax Molybdenum Co., Canton, Ohio (August 8, 1948). Member since 1937.

WARD DIX KERLIN, Mechanical Engineer, Philadelphia, Pa. (August 23, 1948). Member since 1919.

FRANK T. POWERS, President, Powers X-ray Products, Inc., Glen Cove, N. Y. Member since 1939.

L. A. Smith, Jones & Laughlin Steel Corp., Aliquippa, Pa. (September 21, 1948). Company representative on Committee C-8 on Refractories, occupying chairmanship of Subcommittee XII on Carbon Refractories.

J. J. SHUMAN. As this BULLETIN is released for press we are advised of the death after a long illness of Jesse J. Shuman, long-time Testing Engineer of Jones & Laughlin Steel Corp. An Honorary Member of the Society and of Committee A-1 on Steel, he had rendered outstanding service to the steel industry and the Society.



"E Coli Destroyed"

Second prize-winning photograph, Photomicrographic Section, Electron Micrograph Group (shadow casting techniques), in the Sixth A.S.T.M. Photographic Exhibit, by M. C. Botty, American Cyanamid Research Laboratory. E coli after destruction by a bactericidal drug (Polymyxin), 16,900X. This specimen was uranium shadowed to enhance observation of structure.

Notes on National Bureau of Standards Personnel

RECENT new appointments in the Bureau of Standards will be of interest to the membership.

H. F. McMURDIE, authority in the field of microstructure, has been appointed Chief of the Constitution and Microstructure Section of the Mineral Products Division. A member of the Bureau staff since 1928, Mr. McMurdie for the past 13 years has been actively engaged in phase-equilibrium studies of systems involving the refractory oxides and in studies of the constitution and microstructure of non-metallic mineral products. His application of X-ray diffraction and electron microscopy has resulted in valuable contributions to such diverse fields of science as the composition of inorganic cements and of the clay minerals, the chemistry of reactions in dry batteries, and the constitution of rubber.

NOLAN D. MITCHELL, prominent in architectural and engineering fields, has been appointed Chief of the Fire Protection Section, where he will direct further research for the Building Technology Division on problems of fire resistance in relation to the design and construction of buildings and building materials. Mr. Mitchell has been on the staff of the Bureau since 1922 and has made many important contributions in the fire protection field, an outstanding example of which is his investigation of the control of airplane hangar fires by the automatic application of water. His research on the fire-resistant properties of structural materials, such as metal-framed and wood-framed interior partitions and columns protected by gypsum, has led to the determination of the effects of fire and the time in which a wall, floor, or other structural element will retard the spread of fire; improved methods of temperature measurements; and the standardization of fire tests. A member of A.S.T.M. since 1923, Mr. Mitchell has rendered service on various technical committees.

EDWARD WICHERS, formerly Assistant Chief of the Chemistry Division, has succeeded G. E. F. Lundell as Chief of the Chemistry Division of the Bureau. Dr.

Wichers is a consulting member of A.S.T.M. Committee E-3 on Chemical Analysis of Metals. A native of Zeeland, Mich., Dr. Wichers graduated from Hope College and received his Ph.D. from the University of Illinois in 1917. (Hope awarded him the honorary degree of Doctor of Science in 1941.) He has been at the Bureau since 1917. He has been active in the work of the American Chemical Society and is a member of the Washington Academy.

NOTE.—In the October, 1947, BULLETIN there was an article on the National Bureau of Standards, with a tabulation of Bureau chiefs and assistant chiefs and division heads.

News of Instrument Companies and Personnel

ON JUNE 3, 1948, BROWN & SHARPE MANUFACTURING CO. purchased the JOHANSSON DIVISION from the Ford Motor Co., with all rights to manufacture and distribute Johansson Gage Blocks and Accessories throughout the Western Hemisphere. Brown & Sharpe has acquired special equipment and processes including a stock of thoroughly seasoned Johansson Gage Blocks and Accessories. This stock will be available to supply industry's requirements until Brown & Sharpe is in production of full-standard Johansson Gage Blocks and Accessories in special quarters at its own plant in Providence, R. I.

The appointment of Howard Kapner to be in charge of the new Glass Section of the laboratories of SAM TOUR & CO., INC., engineers, metallurgists, consultants, has been announced by Mr. Tour. Mr. Kapner, who has made a study and hobby of glass technology for eight years and who has been in the laboratories of Sam Tour & Co. Inc., for the last year, will handle all testing, laboratory and research work on glass. Located in the company's building at 44 Trinity Place, New York, Mr. Kapner's office and laboratory equipment will occupy space recently made available.

The name of LANCASTER IRON WORKS, INC., has been changed to POSEY IRON WORKS, INC. The change was made through action of the Board of Directors in order to honor the President and founder

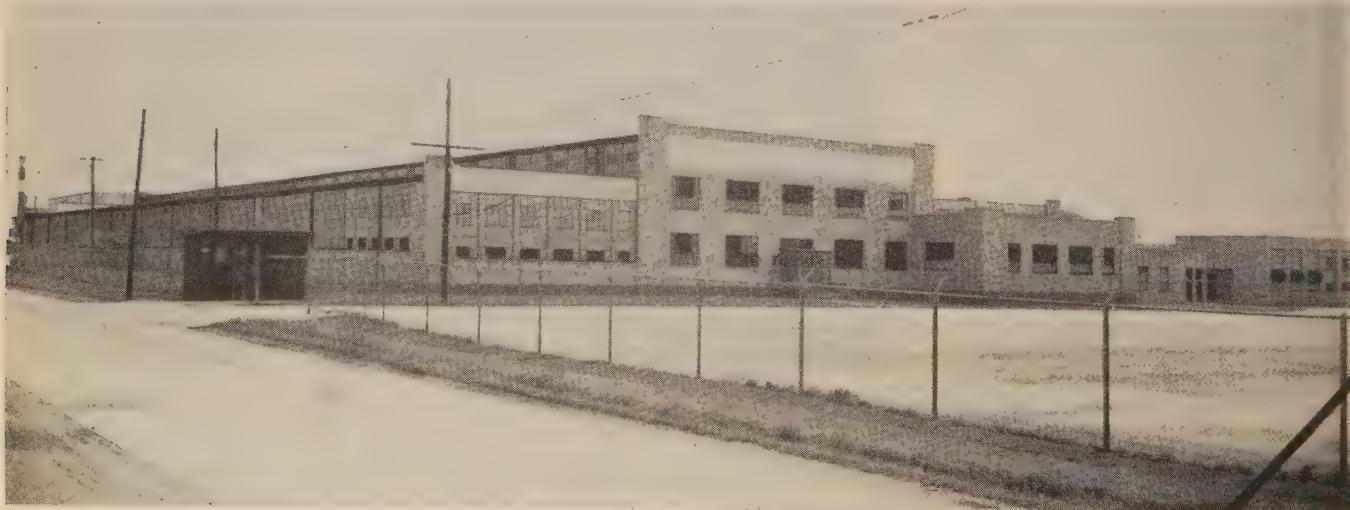
of the organization, Mr. W. W. Posey. No other change in the corporate setup has been made and the same personnel and management continue to direct the functions of the organization. The respective divisions of the company are also being continued under their former identifications. The company is located in Lancaster, Pa.

Tinius Olsen Acquires New Plant

THE Tinius Olsen Testing Machine Co., pioneering manufacturers of testing and balancing machines, have acquired a new plant near Willow Grove, Pa., on Easton Road on the way toward Doylestown. The accompanying photograph shows the building purchased. It is a completely modern plant with about 70,000 sq. ft. in one building on one floor, the total coverage being about 100,000 sq. ft., including storage buildings, physical testing laboratory, storage barn, farmhouse, and a complete 225-car parking lot. It is situated on a plot of ground of about 11½ acres, next to the Willow Grove Naval Air Station. The plant provides a modern production layout, permitting use of modern materials handling equipment, and there is plenty of room for expansion.

The large number of customers and friends of the Olsen Co. in the Society will be interested in this move which, although it takes the company's headquarters and plant from the city of Philadelphia where it has been located for many, many years, nevertheless does provide badly needed additional facilities.

For upward of 70 years the Olsen Co. has been a leader in its field and has a wide range of all types of instruments and machines for evaluating various materials and products. Members of the company and its staff have been active in the work of A.S.T.M. for many years, the present representative of the company membership being George Criswell Lawrie. Tinius Olsen, 2d, Vice-President, is active and serves as Secretary of the Philadelphia District Council. Bruce Lewis, staff member, is Secretary of Committee D-20 on Plastics.



New Olsen Plant

Notes on Laboratory Supplies

Catalogs and Literature, Notes on New or Improved Apparatus

This information is based on literature and statements from apparatus manufacturers and laboratory supply houses.

Catalogs and Literature:

BURRELL TECHNICAL SUPPLY Co., 1942 Fifth Ave., Pittsburgh 19, Pa. Bulletin No. 213, entitled "Burrell Industro Gas Analyzers" describes analyzers, gives simple operating procedure, structural features, price list. Illustrated. Eight pages, 8½ by 11 in. page size.

GEORGE SCHERR Co., INC., 200 Lafayette St., New York 12, N. Y. A new 28-page Small Tool Catalog presents the company's line of Micrometers, Vernier Calipers, Height Gages, and other machinist's tools for toolmakers and mechanics. The book also introduces a number of newly developed specialties that will be of interest to everyone who does precision work. Also described are the Scherr Magni-Rays, a new Dial Thickness Measure, the Optical Center Locator, Quartz Optical Flats, and other products. The booklet also announces the establishment of a Book Department for the company which will specialize in useful books or machine shop work.

LEEDS & NORTHRUP Co., 4934 Stenton Ave., Philadelphia 44, Pa. A newly revised 36-page catalog presents the latest developments in the company's Duration-Adjusting Type of L&N Electric Control for regulating temperature of electric furnaces, salt pots, and certain fuel-fired furnaces. Illustrated with numerous pictures of actual installations, this publication describes the D.A.T. method for controlling heat input by supplying electric power in impulses of controlled duration. In addition to the Micromax control instruments, the catalog also lists the Speedomax line of controllers for applications where unusual speed and sensitivity are required.

RANDALL AND SONS, 2512 Etna St., Berkeley 4, Calif. Information Circular 2, entitled "What to Do About Mercury Vapor," answers many questions about the toxicity of mercury vapor and its control. Information Circular No. 3 describes the application of the step plated Bearing Corrosion Test Strip to determine the onset of corrosive characteristics in crankcase oils in use. The use of the strip to obtain supplemental information in connection with the Chevrolet L-4 test and several recent laboratory evaluation tests is outlined. The test strip gives a closer correlation of bearing corrosion than does the neutralization number.

RAYMOND M. WILMOTTE, INC., 1469 Church St., N. W., Washington 5, D. C. A brochure covering the Wilmotte Vision-Limit Micrometer, an electronic instrument capable of measuring the dimension of an object while it is moving rapidly and vibrating. The instrument can be used to measure the outside diameter of wire, thread, tubing, rod, edge to edge dimension of extruded parts, strip stock, etc.

TAYLOR INSTRUMENT Cos., Sustaining Members of A.S.T.M., have issued a new quarterly house organ entitled "Taylor Technology." A statement by Lewis

B. Swift, President of the company, indicates that it will be the policy of the editorial board, with Charles W. Covey, Editor, "to bring through the pages of this magazine, useful and valuable information concerning all phases of industrial process instrumentation. In addition to data concerning Taylor products and their application, information dealing with the fundamentals of instruments, training and organization of maintenance personnel, and theoretical aspects of instrumentation will appear. From time to time, articles will be published concerning our household, medical and scientific consumer products." The first issue of "Taylor Technology" discussed bleaching of paper pulp, processing synthetic rubber, solvent extraction of cottonseed oil, purge and seal systems for instrument protection, stainless steel aneroid manometer for flow and liquid level, and a streamlined, hermetically sealed sanitary thermometer.

THE BALDWIN LOCOMOTIVE WORKS, Philadelphia 42, Pa. A series of booklets and pamphlets describing dynamic testing machines and equipment and other items in the extensive line of instruments issued by the Baldwin company.

Bulletin 257—Sonntag Universal Fatigue and Simulated Service Testing Machine—Model SF-20-U. A versatile machine for fatigue and simulated service tests.

Bulletin 258—Sonntag Universal Fatigue and Simulated Service Testing Machines—Models SF-01-U and SF-1-U. Designed for the testing of machine elements, structural components and materials, in tension, compression, bending, torsion or combined stresses.

Bulletin 266—Lazan Oscillator—a compact, portable, easy-to-operate machine for inducing controlled vibrations in structures and assemblies.

Bulletin 256—Sonntag Fatigue Machine—Model SF-2. This is a small, light, motor-driven unit for testing sheet materials in flexure under repeated bending moments.

Bulletin 268—Sonntag Fatigue Machine—Model SF-4. The first "constant-force" fatigue machine designed to permit the application of furnace and control equipment for direct stress fatigue testing at elevated temperatures.

Bulletin 259—Sonntag Rotating Beam Fatigue Machine—designed to extend the usefulness of this method of testing by providing greater capacity and increasing the size of specimens that can be accommodated.

Instrument Notes:

NEW LOW-RANGE PRESSURE CELLS—THE BALDWIN LOCOMOTIVE WORKS, Philadelphia 42, Pa. Three new SR-4 Fluid Pressure Cells extending the available ranges down to 0 to 200 psi., one-tenth of the previous minimum range. Higher accuracy within each range is the principal advantage gained. Calibration accuracy of all cells at any pressure is within plus or minus 1 per cent of full range.

CREEP TESTING MACHINE—a new motor-driven, screw-type creep testing ma-

chine of 20,000 lb. capacity, designed for short-time, creep-rupture tests at high temperatures, with a minimum of operator attention. The machine automatically maintains constant loads up to 100,000 psi. on standard 0.505-in. diameter specimens while temperatures are held constant up to 2200 F. Tests of this type may run for 10 to 400 hours.

A NEW TYPE HORIZONTAL TENSILE TESTING MACHINE—designed especially for long specimens of rope, wire, cable, chain, belting and like flexible tensional materials of any desired length.

CERAMIC COMBUSTION BOATS—LABORATORY EQUIPMENT CORP., 720 E. Main St., Benton Harbor, Mich. This company has announced that it plans to continue the manufacture of ceramic combustion boats. One other large manufacturer has recently discontinued these, but LECO is maintaining large stocks ready for prompt shipment. Further information and prices, etc., can be obtained from the company.

AQUET—THE EMIL GREINER Co., 161 Sixth Ave., New York, N. Y. A new and efficient surface-active agent compounded by Greiner. This new cleanser, especially designed for laboratory use, leaves only a slight film of water, allowing glassware to dry sparkling clean, quickly. Aquet is nonionic and therefore stable in the presence of acids and bases. Producing suds much faster than any soap, Aquet is a solution of an aromatic polyglycol ether which actually cuts away grease by preferentially adhering to the glass. Surface tension lowering produces a high emulsion action. If water is used at 100 F. glassware will dry in two minutes on a rack, it is claimed. Aquet is particularly adapted for cleaning burets to eliminate drainage errors.

FLOWMETERS—THE EMIL GREINER Co. For the first time, an inexpensive rotometer custom-built for the laboratory. Model G9146 for small flows covers 30–900 cc./min. by using two Ball Floats (steel and glass) in same tube. (8 mm. O.D., 9½ in. long). Model G9147 is for larger flows and covers 1000 to 38,000 cc./min. (12 mm. O.D., 9½ in. long). Calibration chart for air flow furnished with each meter. Standard tapered joints available at small additional charge.

STAINLESS STEEL LABORATORY BEAKER—THE EMIL GREINER Co. Model G1785, sturdy stainless steel 500-ml. beaker with pour out and convenient welded handle.

STOPCOCK ADAPTER—THE EMIL GREINER Co. For 2-mm. Kimble Buret Stopcocks.

FIVE NEWS ITEMS—SEE-ALL THREAD STAGING FIXTURE, "NORMAL TO HELIX" THREAD CHARTS, THREAD CHART GAGE SCREENS, ESD MAGNIFICATION CHECKER, MAGNIFICATION CHECKING SCALE—ENGINEERS SPECIALTIES DIVISION, THE UNIVERSAL ENGRAVING & COLORPLATE CO., INC., 980 Ellicott St., Buffalo 8, N. Y.

SEE-ALL THREAD STAGING FIXTURE is a universal type for the inspection by optical projection of screw threads ranging in diameter from 0.073 in. to 1.000 in. It is designed for use on AO Optical Projection Comparators, Kodak Contour Projectors, Jones and Lamson Optical Comparators, and Model P.25 Portmand Comparators. It provides both practicable and fast methods of loading and holding screw threads.

"NORMAL TO HELIX" THREAD CHARTS are now available for those whose gaging practice requires the staging of American National Form threads to the correct helix angle. Designed for use in conjunction with the See-All Thread Staging Fixture, they are also planned for Thread Checking wherever threads are held by centers and the helix adjustment is taken into account.

"NORMAL TO HELIX" THREAD CHART GAGE SCREENS cover the range of standard thread sizes for Class 2 and Class 3 fit. As these threads are gaged normal to the helix, requiring a corrected pitch for the requisite helix angle, a separate contour is shown for every thread size.

ESD MAGNIFICATION CHECKER quickly and accurately checks the mirror adjustments and the magnifications of the lenses of all types of Optical Comparators and Projectors. In many plants the practice of checking mirror adjustments and lens magnification is a prerequisite to the setup of any inspection operation when using Optical Comparators or Projectors. This practice has saved considerable time, and resultant cost by eliminating the possibility of overlooking the mirror adjustment when changing lenses on those comparators which require a re-setting of the mirror for every change of magnification.

MAGNIFICATION CHECKING SCALE used with the ESD Magnification Checker provides a quick and easy means for the inspection of the magnification accuracy of the optical comparator. The precision rulings are on the under side of the selected plate glass of which it is made.

NEW 60° GLOSSMETER AND 45°-0° REFLECTOMETER—HENRY A. GARDNER LABORATORY, INC., 4723 Elm St., Bethesda, Md.

THE GLOSSMETER consists of a prefocus type flashlight lamp mounted in a carefully positioned clamp, a lens directing rays from this lamp onto a test surface, parallel half-round plastic bars on the bottom of the light-tight housing to properly mount the glossmeter on test surface, and an aluminum receptor plate which receives rays reflected in the direction of mirror reflection by the specimen and reflects them onto the sensitive face of the lightmeter. The instrument will measure differences at least as small as any of the eye can detect.

THE PORTABLE REFLECTOMETER, 9 by 3½ by 4 in., contains a flashlight reflector directing a beam of light into the 2-in. circular opening in the black plastic block on the bottom of the instrument. Directly about this 2-in. opening is the sensitive face of a lightmeter which is covered with a green, visual-correction filter. Measurements with the new apparatus are not satisfactory for opacity or hiding power determinations because the precision is not high enough. For most other purposes for which reflectance measurements are made, however, the new device is quite suitable.

"PRECISION" SOLUTION DISPENSER—PRECISION SCIENTIFIC Co., 3737 W. Cortland St., Chicago 47, Ill. This dispenser was developed for fast and accurate measurement of solutions used for routine testing. Accurate deliveries can be made up to 100 ml. The solution to be dispensed is free from contamination by outside sources. The instrument can be applied to any test where measured quantities of liquids must be dispensed, such as Kahn test, biological assays, water analyses, plant control testing, etc. The "Precision" Solution Dispenser is mounted on a sturdy

base and the valves, etc., are enclosed in a steel case. The reservoir is made of pyrex glass. Liquid in the apparatus is sealed from the atmosphere, so that volatile liquids may be measured.

PRECISION "MODEL S" KINEMATIC VISCOSITY BATH has been designed for Kinematic viscosity determinations with Ostwald, Ubbelohde, or other suspended level viscometers commonly used. The temperature range of the bath is from approximately 70 F. to 212 F., with a sensitivity of plus or minus 0.05 F. or better.

THREE NEW ITEMS—E-Z FLEX BRUSH, CRYSTAL MODEL SETS, MAGNIFIER-ILLUMINATOR.—FISHER SCIENTIFIC Co., 717 Forbes St., Pittsburgh 19, Pa.

E-Z FLEX BRUSH is used for cleaning those "hard to get at" surfaces in flasks and other narrow-mouth vessels. After the nylon bristle portion of the brush is inserted in the flask, a "trigger" at the handle end is moved with the thumb. This trigger controls several springs in a unique arrangement which turns the bristle portion as much as 90 deg., allowing the bristles to reach any spot in the flask.

THE CRYSTAL MODEL SETS consist of rubber balls and cellulose acetate connectors. The rubber balls are 1½ in. in diameter, and the holes ¼ in. in diameter. The colors for contrasting different ions and atoms are red, yellow, and blue. The cellulose acetate connectors come in straight lengths of 1¾ in., 3¾ in., and 10 in., and in arcs 6 in. long, in the same three colors as the balls. Two sets are available—the Master Crystal Set consists of 65 six-hole balls and 35 fourteen-hole balls in assorted colors, red, yellow, and blue; it also contains an assortment of connectors in different colors and lengths. The Auxiliary Crystal Model Set consists of 30 balls with six holes, 30 balls with 14 holes, and 24 ten-in. lengths of connectors to supplement those in the Master Crystal Set.

THE MAGNIFIER-ILLUMINATOR combines in one unit the means for lighting and enlarging objects for visual inspection or fine work in laboratories. The compact viewing head of the new unit contains the light source and a high-grade 5-in. lens which brings objects into sharp focus at 13 in. The triangle-shaped lens and lamp housing may be suspended above the work in any desired position at the touch of a hand and the whole assembly can be quickly clamped to the edge of the laboratory bench, desk, or table.

NYLAB FILTER-GRIP—NEW YORK LABORATORY SUPPLY Co., Inc., 78 Varick St., New York 13, N. Y. This Grip is a flat, soft rubber cylinder which provides a novel and efficient means of vacuum filtration with Büchner funnels. It obviates the need for tubulated filtering flasks in sizes of 250 ml. or greater. This Grip is used as a support for small round-bottom flasks.

Also, THE NYLAB VAC-U-MAT—a new aid to vacuum filtration. It prevents spilled filtrates, breakage, and eliminates cumbersome clamping. It is designed to hold the filtering flask securely to the bench top. Since it can be left permanently connected to the vacuum line, the Vac-U-Mat is in place and ready for use at all times. It consists of a flat circular rubber mat, 5 in. in diameter and ¾ in. thick, with a cylindrical hollow on the under side which serves as a vacuum chamber and which communicates with the

upper surface through an orifice. The Vac-U-Mat holds all standard filtering flasks from 25 ml. to 1000 ml. capacity.

THE KLIX SPEEDY SPIGOT—SCIENTIFIC GLASS APPARATUS Co., 49 Ackerman St., Bloomfield, N. J. This is a practical device for dispensing chemical fluids, alcohols, oils, solvents, glycerin, or any free-flowing noncorrosive liquid from standard 5-gal. cans. The spigot is made principally of copper, cadmium-plated for corrosion resistance. A feature is the air inlet tube, equipped with a ball valve to allow free passage of air into the can, yet sealing the vent against the escape of liquids and vapors.

Also, the GYRO-PHEN ELECTRONIC TEMPERATURE CONTROL—designed to maintain with accuracy any selected temperature within its operating range. This model, M-2, covers a large field of application while maintaining simplicity of operation and control. It is recommended for controlling ovens, hot plates, water baths, laboratory heating jackets, heated molds, immersion heaters, and similar items.

TEMCO ELECTRIC FURNACES—THERMO ELECTRIC MANUFACTURING Co., Dubuque, Iowa. These bench-type TEMCO Electric Furnaces are for laboratory uses and heat treating of carbon and high-chrome steel parts and tools. They are designed as Series 1500, 1600, and 1700. There are six sizes ranging in chamber dimensions from 4 in. wide 3½ in. high and 4½ in. deep to 8½ in. wide 7½ in. high and 18 in. deep. The furnaces are fast heating and may be operated up to 1650 F. for continuous use and to 1900 F. for short periods.

LINDBERG H-5 HOT PLATE—LABORATORY DIVISION OF LINDBERG ENGINEERING Co., 2444 W. Hubbard St., Chicago 12, Ill. This Hot Plate has been designed to aid the laboratory technician in his work of extraction, evaporation, and overnight concentration of analytical samples. The new unit has a plate surface area 5 in. wide by 22½ in. long. The long, narrow plate allows the operator to place the flasks and containers side by side, thus permitting an unobstructed view of the action taking place. Plate temperatures are accurately controlled with a knob connected to an input controller mounted integrally on the front of the hot plate.

AMINCO-LARDY ROTARY WARBURG APPARATUS—AMERICAN INSTRUMENT Co. Inc., 8010-8020 Georgia Ave., Silver Spring, Md. This new apparatus has a pivotal shaking action which makes it possible for manometers to be read more easily and accurately (while in motion) than ever before. Manometer legs move radially, in a horizontal plane, about an axis centered between them; thus each manometer leg moves in a direction opposite to the other, causing inertia effects to be balanced and eliminating fluctuations of the liquid columns. All manometers can be read while the operator remains in a fixed position. The new apparatus accommodates various types of manometers and has three selective speeds of oscillation (70, 112, or 180 oscillations per minute). The apparatus is available in either a heated model or a combination heated and refrigerated model.

New Type Weighted Needles for Determining the Setting Time of Magnesium Oxychloride Cements*

By Harry E. Chisholm¹

SYNOPSIS

Increasing the weights and tip areas and the incorporation of a depth indicator set at 0.015 in. on setting time needles have permitted the determination of initial and final setting times of magnesium oxychloride cements with a greater precision than was possible with the Gillmore needles formerly used. The salient features of the new needles are the increase in weight and tip area to four times those of the corresponding Gillmore needles and the machining of a shoulder of a prescribed diameter 0.015 in. above the tip. The magnitudes of setting times by the new needles and the Gillmore needles are comparable, but the precision expressed as the standard deviation is of the order of 3 to 5 min. for initial set and 3 to 9 min. for final set by the new needles as compared to 7 to 9 min. and 12 to 15 min., respectively, for the Gillmore needles. The ease of selecting the significant indentation corresponding to the setting time of the test specimen is greatly increased by the use of the new needles except in the case of certain granular or highly fibrous mixes.

THE extent of reaction between the magnesia and the magnesium chloride in relation to the age of the resulting magnesium oxychloride cement is of major importance in guiding the timing of certain manipulations in installing and finishing the cement. The initial set and final set, respectively, between which most of the manipulations are performed, are measured empirically as the ages at which the reaction in the cement has imparted strengths sufficient to resist penetration of blunt rods of prescribed sizes and weights. For many years the initial and final setting times have been determined with the Gillmore needles². In the study of methods of testing sponsored by the Oxychloride Cement Association, it became apparent that the Gillmore needles were not entirely satisfactory. Not only was it difficult for even an experienced technician to obtain reproducible results, but different operators frequently failed to agree on the reading corresponding to set of the speci-

men. This difficulty arose because the needles marked the surface of the specimens for an appreciable time after the practical point of set.

TESTING CONDITIONS AND SAMPLE PREPARATION

All mixing, sample preparation, and specimen testing were performed in an atmosphere maintained at 70 ± 1 F. and 50 ± 5 per cent relative humidity and in accordance with tentative methods of the Oxychloride Cement Assn. A standard testing mix for evaluating oxychloride grade magnesia was used, which consisted of 30 parts by weight of magnesia, 3 parts of standard short fiber asbestos, 15 parts of ground silica, and 52 parts of standard minus 20 to plus 30-mesh testing sand. These ingredients were mixed in a prescribed manner in a mechanical mixer to a standard consistency with a solution of ten parts by weight of magnesium chloride hexahydrate to one part of magnesium sulfate heptahydrate, dissolved in distilled water, and adjusted to a specific gravity of 1.198 ± 0.001 . The test specimens for the determination of setting time were cast $\frac{1}{2}$ in. thick in a ring mold and placed on the traveling carriage of a modified Hill setting time machine.³ This machine applied the setting time needles gently to the specimen at a uniform frequency and moved the

specimen horizontally so the needle indentations would not overlap.

OBSERVATIONS AND PROCEDURE

It was found that upon increasing the area of the needle tip and the weight proportionately so as to maintain the same pressure on the test specimen as obtained with the Gillmore needles (47 psi. for the initial set needle and 722 psi. for the final set needle), the resulting indentations were more uniform and were less influenced by irregularities on the surface of the test specimen. The difficulties in selecting the indentation corresponding to set of the cement, however, were not significantly reduced. Measurement of the depths of the indentations with a depth micrometer and the establishment of a value to correspond to set, while an improvement, were tedious and not entirely satisfactory.

It was observed that the configurations of the series of indentations in the test specimen during the course of setting while on the modified Hill setting time machine could be classified into five well-defined phases: (1) The cement was relatively fluid and the indentations tended to refill because of the flow of the material and the suction of the needle. (2) The cement became stiffer; the indentations were well defined and were of a uniform depth at the maximum penetration of the

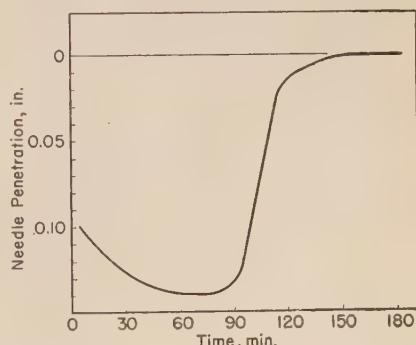


Fig. 1.—Typical Time-Needle Penetration Curve During Setting of Magnesium Oxychloride Cement.

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* Presented at the Fifty-first Annual Meeting, Am. Soc. Testing Mats., Detroit, Mich., June 21-25, 1948.

¹ Research Chemist, Westvaco Chemical Corp., Newark, Calif.

² Standard Methods of Test for Time of Setting of Hydraulic Cement by the Vicat or Gillmore Needles (C 191 - 44), 1946 Book of A.S.T.M. Standards, Part II, p. 86.

³ The Dow Chemical Co., "Plastic Magnesia Cements," Magnesium Chloride Service Bulletin No. 9, pp. 79-82 (1927).

TABLE I.—INITIAL SETTING TIME, MINUTES.

Test	Westvaco Needle			Gillmore Needle		
	\bar{X}^a	σ^b	n	\bar{X}^a	σ^b	n
No. 1.....	131	3.9	9	140	7.6	9
No. 2.....	131	3.3	9	135	8.3	9
No. 3.....	131	4.2	9	136	8.5	9
No. 4.....	134	5.2	9	137	7.8	9
No. 5.....	131	4.3	9	138	6.5	9
No. 6.....	134	5.1	9	144	8.9	9
No. 7.....	131	5.4	9	137	7.2	9
No. 8.....	122	4.3	10			
No. 9.....	142	4.4	10			
No. 10.....	170	4.8	10			
No. 11.....	172	5.0	10			
No. 12.....	138	3.5	10			
No. 13.....	140	3.8	10			
No. 14.....	134	4.4	9			

^a \bar{X} = arithmetical mean of n determinations^b σ = standard deviation.

needle. (3) As the cement began to set, it resisted the penetration of the needle so that the indentations became progressively shallower. The rate of decrease in depth was linear. (4) The indentations continued to decrease in depth, but at a lesser rate than in the preceding phase. (5) Although, for all practical purposes, the cement was set, the needle continued to mark the surface of the specimen for a moderate length of time. The relative duration of each phase depended on the activity of the magnesia and the nature and proportions of the inert ingredients. An illustration of these phases for a typical specimen is given in Fig. 1.

The transition between phases three and four was readily discernible and, in almost every case, occurred at indentation depths of between 0.012 and 0.018 in. This suggested the possibility of incorporating a depth gage or stop with the setting time needle to give a visible indication of the transition at an average indentation depth of 0.015 in. Consequently, this concept was combined with the larger needles as a further improvement over the Gillmore needles. Mechanical considerations limited the weights of the new needles to four times those of the Gillmore needles.

A needle for determining initial setting time was fabricated from stainless steel rod by machining one end of a 6-in. piece to 0.250 in. in diameter. A shoulder was then machined so as to produce a projecting cylindrical tip 0.167 in. in diameter by 0.015 in. long. The tip and the shoulder were concentric with the rod. The end of the tip and the face of the shoulder were plane and perpendicular to the axis of the rod. The rod was symmetrically loaded about its axis with lead so as to weigh 1 lb. These large shoulder needles will hereafter be referred to as Westvaco needles.

In use, the Westvaco needles produced two concentric indentations which, as the specimen attained set, changed sharply so that only the small, inner indentation was made. In some cases where the surface of the specimen was not plane, the shoulder of the needle marked a small segment of the outer ring. In selecting the setting time, the significant indentation was taken to be

using ten identical specimens from each cement mix (Table I, tests 8 to 14, inclusive) showed the precision with the Westvaco needle to be reasonably constant and to be relatively unaffected by moderate variations in the magnitude of the initial setting time.

A Westvaco needle for determining final setting time was developed in a manner similar to that of the

TABLE II.—FINAL SETTING TIME, MINUTES.

Test	Westvaco Needle			Gillmore Needle		
	\bar{X}^a	σ^b	n	\bar{X}^a	σ^b	n
No. 1.....	221	5.9	12	243	14.8	
No. 2.....	147	3.3	12	167	11.7	
No. 3.....	228	8.8	10			
No. 4.....	225	7.3	10			
No. 5.....	221	5.8	10			

^a \bar{X} = arithmetical mean of n determinations^b σ = standard deviation.

the first of two consecutive indentations where the shoulder failed to mark the surface of the specimen. The ease of selecting the significant indentation was considerably better than with the Gillmore needle. Also an operator could duplicate the selection of indentations on different days and different operators agreed among themselves.

In order to compare the magnitudes and precisions of initial setting time by the Westvaco and the Gillmore needles, nine identical specimens were prepared and tested simultaneously from each of seven magnesium oxychloride cement mixes. The two types of needles were paired for each specimen and were applied by the modified Hill setting time machine at a uniform frequency of ten times per hour. The averages for initial setting time (Table I) were sufficiently close to each other to indicate the two types of needles to be interchangeable. The standard deviation of the Westvaco needles, however, was approximately half that of the Gillmore needles. Several additional tests

initial setting time needle. The needle weighed 4 lb. and had a 0.083-in. diameter by 0.015-in. long tip projecting beyond the 0.167-in. diameter shoulder. The fabrication specifications of the initial and final setting time needles are given Table III, and the needle tips a

TABLE III.—WESTVACO SETTING TIME NEEDLES SPECIFICATIONS.

	Initial Needle	Final Needle
Weight, g.....	453.6 ± 0.5	1814.4 ± 1
Shoulder diameter, in.....	0.250 ± 0.002	0.167 ± 0.002
Tip diameter, in.....	0.167 ± 0.002	0.083 ± 0.002
Tip length, in.....	0.015 ± 0.001	0.015 ± 0.001

shown in Fig. 2. A comparison of the Westvaco and Gillmore final setting time needles on two series of twelve identical specimens (Table II) showed that the standard deviation of the former was only one-third that of the latter. The average values by the Westvaco final needle were slightly shorter than those by the Gillmore needle, but the difference was relatively unimportant as compared to the improvement in precision.

Although designed for use with the standard magnesia testing formula, the Westvaco needles are suitable for use with a wide variety of cementitious mixes. They are not superior to the Gillmore needles in precision and ease of use for very granular or highly fibrous mixes in which the particles bridge the angle between the tip and shoulder so

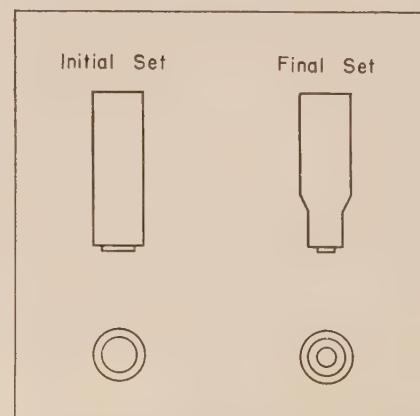


Fig. 2.—Tips of Westvaco Setting Time Needles.

produce a dished depression other than the well-defined concentric indentations.

CONCLUSION

The large, weighted (Westvaco)

needles with the shoulder feature are superior to the Gillmore needles in ease of use and reproducibility of results in determining the initial and final setting times of magnesium

oxychloride cements excepting very granular or highly fibrous mixes. The magnitude of the setting times are comparable for both types of needles.

DISCUSSION

MR. O. HASSE.¹—When these Westvaco needles are applied, is there any part of the test specimen that comes up through the needle so as to make the next hit somewhat inaccurate because the point of the needle is not clean?

MR. H. E. CHISHOLM (*author's closure*).—In reply to Mr. Hasse's question, the cement occasionally adheres to the shaft of the needle above the shoulder during the determination, particularly if the needle is allowed to penetrate the specimen too deeply, but the end point is not obscured. It is our practice to examine the needle tips before each determination and to remove any film or adhering cement. With certain types of mixes we find it desirable to clean the needle tips during the course of the determination.

MR. HERMAN H. MILLER.²—We have been using the automatic setting time

machine for the past 30 yr. It was originally equipped with the old pointed Gillmore needles, later with the modified Gillmore needles. At the present time, we have three automatic machines equipped with three initial and three final setting time needles each. One machine is equipped with the modified Gillmore needles, the other two with the new Westvaco needles.

We feel that the automatic setting time machine equipped with the Westvaco needle has much to offer to those who are interested in testing portland cements or portland-cement mortars and any other materials of similar composition.

MR. G. J. FINK.³—What I have to say is somewhat aside from the question of needles; it refers to the automatic testing machine. I consider the automatic setting-time machine of considerable advantage in the laboratory because of the fact that one can put samples on—as many as desired depending on the width of the bed of the machine and the number of needles—then forget it and the setting time is recorded. There is not necessarily any overtime if one happens to set up samples at four or five o'clock in the afternoon as a record of the setting time is available by the next morning.

¹ Chief Chemist, Monarch Cement Co., Humboldt, Kans.

² Dowflake Technical Service, The Dow Chemical Co., Midland, Mich.

A Visual Rating System for Rusted Steel Specimens

By Harry L. Faigen¹

SYNOPSIS

A convenient system for rating rusted steel surfaces visually is outlined and illustrated. Numbers and letters are employed to designate stages of rusting as defined by verbal descriptions or pictorial representation in a logical and easily remembered succession of steps. The system provides a convenient "shorthand" which has great elasticity of application, permitting ratings varying from qualitative to semiquantitative nature. It also lends itself to graphical representation and permits definite designations of limits for specification purposes.

HERE is a need for a systematic method of visual evaluation of test specimens, particularly during the early stages of rusting, so that the amount of corrosion encountered can be readily defined and briefly recorded.

It should be emphasized that, in the main, the degree of rusting discussed here falls short of that which appreciably affects the physical properties of

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¹ Supervisor, Rust Preventive Research Section, Rock Island Arsenal Laboratory, Rock Island, Ill.

the metal. Corrosion of this relatively slight degree, however, is of major concern in the sphere of decorative and protective coatings, and for the requirements of agencies such as the armed services, which must prevent the slightest rusting of multitudes of critical bare steel surfaces.

Technical development and research on rust-preventive materials have been handicapped by the absence of a rating system which could be used to record briefly and informatively the behavior of a broad variety of rust-preventive materials during the course of their expo-

sure in accelerated and long-term testing mediums. Because of the very large number of specimens required in such work and the frequent necessity for collection of behavior data by subprofessional personnel, the absence of a simple and uniform rating system causes considerable difficulty. This problem is still more acute when cooperative projects are undertaken and the problem of comparing test results collected by different laboratories is encountered.

A system of visual inspection, which would (1) aid rapid assessment and recording of the appearance of surfaces in the earlier stages of corrosion, and (2) provide a convenient visual adjunct to the weight loss and physical tests applied in the later stages of rusting, would be of considerable utility.

As far as is known, there is no generally accepted system for this type of evaluation. Many laboratories use some brief numerical sequence to designate different degrees of rusting on specimens. In general, these ratings cannot

begin to encompass the vast variety of guises which rusting assumes. As a result, interpretation varies widely within the same laboratory and lack of agreement is the rule. The recognition of this fact has led to a rather extreme solution in at least one large laboratory whose practice has been brought to this author's attention. It makes numerous corrosion tests and is constantly confronted with the necessity of maintaining some type of uniform and duplicable record of the course of the tests. An abbreviated numerical rating system of the type mentioned above is used. For the sake of duplicability, one person is employed for the sole purpose of rating specimens. It is presumed that an understudy having closely related habits of estimation is also maintained, so that occasional absence of the rating authority does not produce catastrophic interruptions of laboratory operation.

Devices less heroic in nature than the one just cited have been employed with regard to other types of corrosion testing. For example, the A.S.T.M. has issued "Photographic Reference Standards"² for rating paint panels with respect to rusting in the presence and absence of blistering. The photographs are useful in their particular field of testing but possess various shortcomings, particularly with respect to general application to the range of corrosion testing here considered. For example, the standards for nonblistered paint panels rate from No. 10, indicating little or no rust, to No. 4, representing a large amount of rusting. The degree of rusting below No. 4 is considered of no practical importance by the Society's Committee D-1 on Paint, Varnish, Lacquer, and Related Products which implemented the standards. For many purposes, ratings below No. 9 of the A.S.T.M. Standard would involve too great a degree of rusting to be practically meaningful beyond the information of secondary importance which would be provided regarding the rate of rusting which could be expected after the inception of appreciable corrosion.

Another type of evaluating device, representing an excellent attack on the problem of rating ferrous and non-ferrous corrosion specimens and couples after immersion type testing, has been presented by Darrin (1).³ This involves the preparation of an evaluation sheet on which most of the conceivable effects of immersion corrosion are listed and weighed numerically on the basis of their importance and extent. The appearance of the specimen, contact metal,

and immersion liquid is indicated by checking the appropriate descriptive phrase or stage of corrosion. The individual numerical scores are then added to yield a composite numerical rating whose magnitude can be used to assign a qualitatively descriptive term varying from perfect (100) to bad (less than 65).

Here again, the specific rating system referred to, while very useful with respect to the type and range of corrosion testing for which it was designed, is not directly or conveniently applicable to that under discussion. Naturally, if this scheme were applied, a different set of qualitative phrases and quantitative weighings would have to be evolved. The use of a printed form for each rating of a single specimen would be somewhat inconvenient because, in the types of accelerated and storage tests here considered, larger numbers of specimens are used and many observations regarding the condition of the specimens are made during the course of testing, in contrast to the single or limited numbers of inspections and specimens of the conventional immersion corrosion tests.

A.S.T.M. Committee B-8 on Electro-deposited Metallic Coatings, through its Subcommittee I on Specifications, Papers, and Definitions, has initiated a promising attack on this problem by sponsoring the excellent papers by H. A. Pray (2), Gustaf Soderberg (3), and W. A. Wesley (4) regarding the visual rating of corrosion on various classes of specimens.

The Rock Island Arsenal Research Laboratory, in the course of conducting technical research on rust-preventive materials, specification development, and examinations of miscellaneous protective coatings, has employed a semi-quantitative rating system (5) with some elements of similarity to these three methods for several years. While the problems encountered here have many facets of resemblance to those treated in the papers referred to above, the armed services have other major problems in this regard which are distinct in some degree from those considered. Army Ordnance, as well as that of the other services, is vitally concerned with a large number of critical applications where surface finish and its unimpaired maintenance are of primary importance. In the production and maintenance of bare steel recoil mechanisms, particularly, and also in that of recuperator assemblies, gun tubes and cylinders, etc., even the slightest rusting may be of significance. On the other hand, large numbers and varieties of coatings for other purposes are examined. Therefore, a single rating system which would (a) incorporate a large spread in numerical ratings for the earli-

est levels of corrosion, (b) permit some degree of qualitatively descriptive notation, and (c) encompass the possibility of rating many classes of coatings, would be most useful for both specification and investigative purposes.

A PROPOSED RATING SYSTEM

A rating procedure which meets most of the requirements noted in the foregoing will be described. It employs both a qualitatively defined numerical system and an idealized pictorial chart which can be used to indicate very briefly the condition of a specimen at any stage of exposure. The present system, or a similar predecessor, has been used with excellent success for several years by a large group of technicians.

It is believed that the rusting encountered on a specimen can be best evaluated by defining the following factors:

1. The *extent* or *area* of the rusting,
2. The *nature* of the rusting,
3. The *intensity* of the rusting, and
4. The *location* of the rusting (when required).

In the proposed rating system, the state of the specimen with respect to each of these factors is briefly indicated by the use of a number or letter based on the accompanying pictorial chart (Fig. 1) and the definitions set forth below. These numbers and letters, defined and pictured in a logical and easily remembered progression, become a simple shorthand for briefly recording the results of inspection of the specimen or specimens in question.

Rating the Area or Extent of Rusting:

The accompanying pictorial chart assigns numerical ratings to the various stages of rusting pictured from 10 for "no rusting" to 0 for "complete rusting." These ratings can be summarized as follows (compare with pictorial chart):

Numerical Rating	Corresponding		
	Rust Dots (d)	Rust Spots (s)	Sim. Rat. Area (a)
10.....	None	None	No rusting
9.....	2 or	1	
7.....	4 or	2 or	
5.....	8 or	4 or	
3.....	16 or	8 or	
1.....	32 or	16 or	
0.....	Complete rusting		

As can be seen, the rating units from 10 to 0 are not evenly divided with respect to the extent of rusting. The rating scale from 10 to 1 is greatly expanded and is accompanied by definitions and idealized pictures to describe the relatively early stages of rusting. This

² Standard Method for Evaluating Degree of Resistance to Rusting Obtained with Paint on Iron or Steel Surfaces (D 610 - 43), 1946 Book of A.S.T.M. Standards, Part II, p. 1186.

³ The boldface numbers in parentheses refer to the list of references appended to this paper.

Fig. 1.—Pictorial Chart for the Rating of Rusted Steel Specimens.
Corresponding Description.

Numerical Rating	Rust Dots (d)	Rust Spots (s)	Small Rust Areas (a)
10	No Rusting	None	
9	2 Rust dots per surface	or 1 Rust spot per surface or 2 Rust spots per surface	1 Small rust area per surface
7	4 Rust dots per surface		2 Small rust areas per surface
5	8 Rust dots per surface	or 4 Rust spots per surface	4 Small rust areas per surface
3	16 Rust dots per surface	or 8 Rust spots per surface	8 Small rust areas per surface
1	32 Rust dots per surface	or 16 Rust spots per surface	16 Small rust areas per surface
0	Complete Rusting		

done so that small amounts of rusting, descriptions of which are important for specification reference purposes or in competitively evaluating the protective-ness of corrosion-preventive coatings, may be readily designated. Where required, intermediate conditions of rusting can be indicated by the use of intermediate numbers or decimals.

More extensive rusting than that pictured in the ratings from 10 to 1 can be readily designated by using decimals between 1 and 0. These decimals should indicate the area of the significant surface of the specimen or specimens which remains unrust. For example, a rating of 0.95 indicates that 95 per cent of the significant surface in question is free of rust. A rating of 0.5 indicates that half of the surface is free of rust. A rating of 0.1 indicates that 90 per cent of the specimen surface is rusted, leaving only one-tenth of the significant surface free of rust.

Rating the Nature of the Rusting:

Besides the extent of rusting in terms of the area of the surface affected, it is frequently desirable to indicate the *nature* of the rusting. The nature of the rusting which may be encountered is arbitrarily defined in terms of "rust dots," "rust spots," "small rust areas," and "large rust areas," abbreviated "d," "s," "a," and "A," respectively, and their combinations. These are dimensionally qualified as follows:

Nature of the Rusting	Abbreviation	Maximum Linear Dimension, mm.
Rust dot.....	d	1
Rust spot.....	s	2
Small rust area.....	a	4
Large rust area.....	A	Larger than 4

Using the numerical scale and letter abbreviations, the manner of quickly compounding a rating representing the extent and nature of the rusting can be readily illustrated. If, for example, the specimen exhibits four rust dots or two rust spots or one small rust area or any equivalent combination of these, the corresponding ratings would be as follows:

Description	Corresponding Rating
4 rust dots.....	7/d
2 rust spots.....	7/s
1 small rust area.....	7/a
1 rust spot and 2 rust dots	7/ds

Obviously any combination of dots, spots, small and large areas may be encountered on a specimen, while the idealized chart, of necessity, is limited in its representation to single categories of these. However, it is easy to compare the specimen with the pictured series

and visually assess its approximate position in the sequence of ratings.

The method employed can be further illustrated by a more complicated example. For example, if the rusting encountered on a group of specimens averages approximately 16 rust dots per specimen, the corresponding rating would be 3/d. If a combination of rust dots, spots, and small rust areas, totaling to an amount of rusting indicated by the rating "3," were encountered, the corresponding rating would be 3/dsa. If the rusting were intermediate between ratings of 3 and 1 in amount, the corresponding designation would be 2/dsa. Underlining the appropriate letter or letters would indicate predominance of the type of rusting indicated. For example, a rating 3/dsaA would indicate the predominance of small and large rust areas as well as the presence of rust dots and spots.

It is apparent that this rating procedure has great flexibility of application. If a single specimen is involved and it is desired to make a rating of semi-quantitative nature, this may be done by equating types of rusting on the basis indicated, that is, one small rust area = two rust spots = four rust dots. Large rusted areas may be rated in terms of the estimated small rust areas of maximum dimension to which they are equivalent. A piece of transparent plastic ruled with 4-mm. squares may be used as an aid. For example, suppose a corrosion panel exhibited a large rust area, two spots, and approximately sixteen rust dots. If the large rust area were judged to be approximately equivalent to two small areas in size, the rusting would equal eight rust dots for the large rust area, and four rust dots for the two small rust areas. The total rusting would, therefore, be equivalent to $8 + 4 + 16 = 28$ rust dots and the corresponding semi-quantitative rating would be 1.5/dsA.

Thus the rating method can be used freely as a convenient shorthand, varying in its manner of application from qualitative estimation by direct visual comparison with the pictorial chart to more quantitative assessment by counting and equating dots, spots, etc., though the latter procedure is rarely necessary or profitable, except perhaps where a specification limit of rusting has been set.

It will be noted that the pictorial chart employs pictures of widely used conventional, 2 by 3-in. corrosion panels to represent the various stages of rusting indicated. This was purely for purposes of convenience and was not meant to imply limitation of basis area. The rating criteria can be applied to any convenient area, size, or shape of specimen agreed upon. They may be applied per unit area of specimen surface, for example, per square foot, by citing the pertinent rating indicating the desired degree of permissible rusting for that unit of surface area.

Rating the Intensity of Rusting:

If desired, a term representing the intensity of the rusting can be added to the rating. The intensity of rusting may be arbitrarily defined by the numerical scale of Table I.

TABLE I.—INTENSITY OF RUSTING

Rating	Definition of Intensity
10...	No rusting
9...	Very slight.—Yellow stain or other indication of incipient corrosion but no appreciable etching or pitting of surface
7...	Slight.—Meager corrosion products; perceptible etching or pitting of steel surface
5...	Moderate.—Corrosion products of medium quantity or definite but no marked etching or pitting
3...	Heavy.—Marked buildup of corrosion products or marked pitting or etching
1...	Very Heavy.—Very profuse corrosion product buildup or deep pitting of steel surface
0...	Extreme.—Extreme pitting and buildup of corrosion products

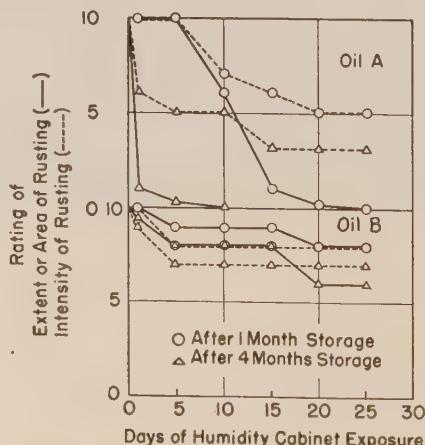


Fig. 2.—Use of the Proposed Numerical Rating System for the Graphical Representation of the Course of Rusting of Corrosion Specimens.

It should be mentioned that the nature of the lighting under which inspection is made markedly influences the appearance and the perception of rusting. To insure uniform conditions of inspection, the use of a fluorescent light source held close to the specimen is desirable. Fluorescent analytical balance illuminators which can be mounted on stands have been found very convenient for this purpose.

Indicating the Location of the Rusting:

Where it is considered necessary, the location of rusting which may be localized, can be indicated by conveniently single letter abbreviations added to the rating. Abbreviations of this type which come to mind, are "e" for rust at edges, "f" for face rust, etc.

convenient device which has been used, either alone or to supplement the numerical ratings, is to pencil in the location of rust dots, spots, areas, etc., on small sketch of the specimen. This procedure is valuable if it is desired to note the location of rusting chronologically as it appears during the course of exposure test.

Compounding the Total Rating:

For much work, ratings involving the first two or three factors discussed will be sufficient. Rating the factors in the order indicated, that is, (1) extent of rusting, (2) nature of rusting, (3) intensity of rusting, is recommended for purposes of standardization. A fourth letter or symbol indicating location of rusting in the manner described above may be added if desired.

Various methods of employing the rating system will be further illustrated by the comments and illustrations in Table II.

The "Intensity of Rusting" graphs are of interest in representing qualitative differences and also in indicating that even when rusting became widespread, the oils provided appreciable inhibition with respect to the intensity factor.

DISCUSSION

As is the case with all arbitrary "shorthand" systems of rating or description which attempt to encompass wide varieties of specimen appearance, the procedure described above may seem somewhat complicated on first reading. However, the method has been readily and successfully employed by subprofessional personnel in this laboratory with no apparent difficulty.

The geometric series defining area or extent of rusting here employed is not as simple and direct as Wesley's linear percentage series, but is better suited to the purpose for which it was devised, namely, the recording of minute degrees of rusting to accommodate current Gov-

ernment rust-preventive specification requirements. In general, the limitation of rusted areas to dots and spots of 2-mm. maximum diameter is not too well suited to the behavior of temporary rust-preventive materials, although it may be perfectly practical for the types of coatings discussed by Wesley.

The area of specimen is obviously very important with respect to the number of anodic areas or rust dots or spots that develop. Direct visual assessment with respect to pictorial standards is of course facilitated by fixing specimen size, which undoubtedly would be the case in national standardization. Where specimens vary in size and shape, however, experience here indicates that direct visual comparison with pictorial standards is difficult, and when using the system here discussed, most technicians apparently resort to a visual summing up of the size and numbers of corroded dots, spots and areas and translate this into the specific shorthand of the rating sys-

TABLE II.—COMMENTS AND EXAMPLES

Comments	Verbal Description of the Specimen or Specimens	Corresponding Rating	
Example 1: The rating of a single specimen can be estimated by direct visual comparison with the pictorial chart.	The specimen has one large rust area (equivalent in size to approximately 2 small rust areas), 1 spot, and approximately 20 rust dots, all of slight intensity. Upon visual comparison with the pictorial chart, the rating indicated is estimated as.....	1/dsA/7	forty similar specimens have been tested under the same conditions but their behavior varies too widely to permit a single estimated rating. The ratings might be summarized as follows:
Example 2: If it is desired to rate the specimen more closely, the rating can be calculated as indicated with regard to the specimen described in Example 1.	1 large rust area = 8 rust dots (Equivalent to 2 small rust areas) 1 spot = 2 rust dots 19 dots = 19 rust dots Total score = 29 rust dots =	1.5/dsA/7	Number of Specimens Rating 2.....10 5.....9-7/dsA/9 13.....6-5-4/dsA/5-6-9 18.....3-2/dsA/5-9 4.....1-0.9/dsA/7
Example 3: For a limited number of specimens, such as triplicate samples of the same material, etc., ratings for individual specimens made in Example 1 or 2 in either be averaged or the range or average of ratings noted without arithmetical adding. Preminence of any effect can be indicated by underlining the appropriate number or letter.	Spec. No. 1—1.5/dsA/7 Spec. No. 2—3/dsA/5 Spec. No. 3—2/ds/5 Average Rating..... Range of Ratings.....	2/dsA/6 1.5-3/dsA/5-7	

Example 4:

For a large number of specimens in a single test group, the pictorial chart may be used by direct comparison to provide a qualitative general rating which most closely fits the average appearance of the specimens. Or the large group of specimens can be divided into subgroups and an appropriate characteristic rating assigned to each group. Thus a lengthy verbal descriptive paragraph can be resolved into a few brief ratings. Suppose, for example, that

RATINGS OF CORROSION PANELS UPON EXPOSURE IN A HUMIDITY CABINET AFTER VARYING PERIODS OF STORAGE.

Days of Exposure in the Humidity Cabinet	Oil A		Oil B	
	After one Month's Storage	After four Months' Storage	After one Month's Storage	After four Months' Storage
1.....	10	1/ds/6	10	9.5/d/9
5.....	10	0.3/dsA/5	9/d/8	8/ds/7
10.....	6/ds/7	0/dsA/5	9/d/8	8/ds/7
15.....	1/ds/6	0/dsA/3	9/d/8	8/ds/7
20.....	0.2/dsA/5	0/dsA/3	8/d/8	6/ds/7
25.....	0/dsA/5	0/dsA/3	8/d/8	6/ds/7

The data tabulated above are represented graphically in Fig. 2. The graphs are very effective in emphasizing the difference in behavior of the two oils. Both oils had passed the AXS-934 humidity cabinet exposure requirement of 200 hr. (8 days and 8 hr.) before storage. After one month of storage, oil A failed the specification requirement (rating of 8 on the "Extent of Rusting" ordinate) after approximately seven days of exposure and permitted rapid progress of corrosion after its inception. Its storage characteristics were poor, as indicated by the graphs of its behavior after one and four months of storage.

The graphs emphasize the superiority of oil B in this regard, demonstrating that this oil provided good inhibition of rusting after its inception and also after some months of storage in contrast to oil A.

tem for the particular specimen involved.

In general, the actual recorded ratings during the period of exposure of the specimens have proved of great value. For reports, however, for the sake of brevity and clarity, average numerical ratings of the extent of rusting factor alone or, when indicated, with the intensity term, are generally recorded. The time factor is taken care of by graphing average numerical score against time of exposure, or by use of total rating-time or percentage scores (6).

As indicated above, the Rock Island Arsenal system includes the following general methods: (a) pictorial representation of the area or extent of rusting in a manner similar to that described by Wesley, (b) the counting method and qualitative description by letter symbol proposed by Pray, and (c) the percentage of total area method of estimation described by both Pray and Soderberg.

This at once suggests the possibility of a fusion of the various methods of attack into a single system which can be used broadly in a standard manner as an A.S.T.M. method, but which is amenable to use in part, *in toto*, or with variations, for recording specialized areas of behavior or for single or limited cooper-

ative endeavors. While the method here described may not satisfactorily answer this need, it is believed that the idea of a broad system of this type should be included in the scope of discussion on this subject, if it has not already been considered.

CONCLUSIONS

The rating system described in the foregoing has the following desirable characteristics:

1. It defines the various factors involved in assessing the degree of rusting encountered, both pictorially and by verbal definition, in a logical succession of steps which are easily remembered after limited use. Thus it organizes and clarifies the observations made on rusted specimens by diverse personnel.
2. It possesses great elasticity of application and can be used as a convenient "shorthand" in a manner varying from qualitatively descriptive to semi-quantitative specification.
3. It is applicable to any number of specimens and can be used to cite a limit of rusting for any size or shape of specimen at any stage of exposure by merely specifying a definite rating for a mutually agreed upon significant surface area.

4. It is capable of graphical representation.

5. It can be readily employed to designate definite ratings for specification requirements limiting rusting of specimens to minute amounts.

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- (6) W. Blum and P. W. C. Strauss, "Outdoor Exposure Tests of Electroplated Nickel and Chromium Coatings on Steel and Non-ferrous Metals," Journal of Research, Nat. Bureau Standards, Vol. 24, p. 443 (1940).

Discussion of the Paper on Quantitative Evaluation of Corrosive Conditions¹ Presented at the 51st Annual Meeting

MR. F. L. LAQUE.²—At the outset I have an important question for the author and the rest of us to answer: Is there any justification for an accelerated corrosion test such as described here?

Unless this question can be answered in the affirmative it is beside the point to discuss the details and refinements of a particular accelerated test. It is evident that the author has provided a technique by which one can measure quite accurately small changes in the condition of a test piece. But the important question remains: What relation does corrosion under these arbitrarily accelerated testing conditions have to performance in practice under the extremely complicated service conditions that are encountered—even in what might be described simply as an "industrial" atmosphere? industrial atmosphere is obscure, and it

The relation between the author's industrial atmosphere and any other

is proper also to question the justification for accelerating corrosion conditions in a particular way so long as materials of interest do not respond alike to the influences of the accelerating factors. For example, it is unlikely that the correlation established for copper would extend even as far as to copper—modified by the addition of alloying elements.

The correlation established by the author for copper is based on the assumption that atmospheric corrosion is a linear function of time. Such a situation is the exception rather than the rule for most metals and alloys subjected to atmospheric corrosion and extrapolations made on such a basis from short time test results are likely to be in error.

But, if we assume the validity of the straight line relationship, then the advantage of the accelerated test becomes questionable in view of the fact that the proposed technique should enable the slope of the natural weight loss *versus* time curve to be determined directly in the length of time required for the accelerated laboratory test.

The next question has to do with detail of the testing technique—the use of foil. It may not be proper to assume that the adhesion of corrosion products to foils, especially those exposed to the atmosphere where they may vibrate and be subjected to rather violent flexure, will be the same as with more massive and more rigid forms. Thus the progress of corrosion of the foil may not necessarily correspond to that of a more substantial section.

It was pointed out that as the test progressed complete failure (represented by infinite resistance) occurred as a result of localized corrosion in way of the foil supports. But it did not seem that this imminent failure was predicted by the slope of the resistance change curve which apparently did not respond to the localized corrosion that must have been going on for some time prior to the eventual failure.

MR. W. F. BONWITT (*author*).—answering Mr. LaQue, I would say that the paper I just presented deals with the method of measuring the rate of cor-

¹ W. F. Bonwitt and I. Eisen, "Quantitative Evaluation of Corrosive Conditions," ASTM BULLETIN, No. 151, March, 1948, p. 84. Presented at the Fifty-first Annual Meeting, Detroit, Mich., June 21–25, 1948.

² In Charge, Corrosion Engineering Section, The International Nickel Co., Inc., New York N. Y.

ion rather than with a salt spray or other accelerated corrosion test procedure. These test procedures as well as a natural corrosion in an industrial atmosphere were only applied to determine the stability of the method under various conditions.

Whether there is justification for accelerated corrosion testing I do not want to discuss here. The fact is, that such accelerated methods are being used widely. Maybe they are more often abused than used properly, but the method discussed should at least provide a means of quantitatively measuring their severity and of comparing them with each other and with natural corrosion such as the industrial atmosphere mentioned in my talk.

I agree with Mr. LaQue that there is nothing "standard" in the particular New York location, and also with his statement that all I have presented applies to copper only. But this in no way affects the method as such, which in my opinion should offer a way of rapidly measuring corrosion wherever it occurs.

If, as the tests seem to show, a straight-line relationship exists between exposure time and resistance increase, the advantage of the methods under discussion over the natural weight loss methods lies in its speed and sensitivity. If a thin enough foil is used, significant resistance changes will occur in hours or days. It is at least doubtful that weight losses produced in such a short intervals can be determined in practice.

I said that the mounting of the foils was not ideal, and I agree with Mr. LaQue that this should be corrected, and also with his thought that the progress of corrosion in a foil may not necessarily correspond to that of a more substantial section. This relationship can probably be established in an experimental way.

As to the last point raised by Mr. LaQue, there was a significant change of slope of the curve of samples which failed through localized corrosion. What I have shown are curves of samples which did not fail in such a way.

MR. H. F. HAASE.³—Many of the members of the Society have had years of experience in corrosion testing and no doubt are becoming disturbed by the indiscriminate use of the salt spray test. It therefore seems to me that the Society should state for what purpose this test should or should not be used. We know that it is a good breakdown test for protective coatings, due to the penetrating action of the chlorine ion. Consequently the Navy had a legitimate use for it, because, after all, they are getting salt spray on the ships, on the exposed metal, and also down inside of the hulls. But when you start to use this salt spray test for every sort of testing purpose for the quantitative rating of various metals, electroplatings or organic coatings, etc., which are to be used in service environments devoid of the chlorine ion, you get misleading results.

³ Associate Professor of Metallurgy, Marquette University, Milwaukee, Wis.

The point is that too many people are accepting the sodium-chloride salt spray for breakdown and general commercial testing. As a consequence the corrosion engineer virtually has to tear his hair out in order to point out the test's limitations.

I think Mr. LaQue will agree with me that this application is one of those cases where the sodium chloride salt spray should not be used. The quantitative correlations obtained between this test and exposure conditions upon a certain roof in New York certainly will not hold for any other location where corrosive environments are different.

MR. H. R. COPSON.⁴—I should like to emphasize the impossibility of the salt spray test, or any accelerated test, reproducing all the diverse results obtained in actual outdoor tests. The data in my paper on "Factors of Importance in the Atmospheric Corrosion Testing of Steel,"⁵ amply illustrate this point.

MR. BONWITT (*author's closure*).—In closing, I should like to repeat that the paper I presented deals with a method of measuring corrosion and its effects, and that the various corrosion test procedures, accelerated and natural, had nothing to do with our work. The purpose of this work was to develop a more convenient and more rapid method for the quantitative evaluation of corrosive conditions than is the natural weight loss method.

⁴ Research Chemist, Research Lab., The International Nickel Co., Inc., Bayonne, N. J.

⁵ *Proceedings, Am. Soc. Testing Mats.*, Vol. 48 (1948).

Closure of Discussion of Paper on Impact Loading of Plastics¹

HALVARD LIANDER (*author's closure, letter*).—Appreciating Dr. Callendar's comments on our paper on the resistance to impact loading of plastics we would like to point out that we have so far confined our work to unnotched test bars because these are easier to treat mathe-

matically. It is our intention to proceed with the much more intricate problem of notched bars, but sufficient experimental evidence is not yet collected.

Working with typically brittle materials, such as phenolic moldings, it is our experience that the break is always quite regular and appears in close agreement with the stress distribution to be expected. (See, for instance, Frocht,

"Photoelasticity," Vol. 2, pp. 106-117.) Laminated materials may of course exhibit a very irregular break, but this fact is of little importance in this connection, as according to our opinion only the energy required to cause the first fissure should be noted.

The wide scatter of test data in some cases should not be connected with an irregular shape of break but rather with the variable properties of the material.

¹ Halvard Liander, Cyril Schaub, and Arthur Asplund, "Investigation of the Resistance to Impact Loading of Plastics," *ASTM BULLETIN*, No. 148, October, 1947, p. 88. Discussion in *ASTM BULLETIN*, No. 153, August, 1948, p. 59.

An Improved Low-Temperature Brittleness Test

By E. F. Smith¹ and G. J. Dienes¹

SYNOPSIS

An improved low-temperature brittleness tester, capable of testing five specimens simultaneously, is described. All machine specifications conform to A.S.T.M. Method D 746-44 T.² Data are presented which show that many elastomers do not possess a sharp brittle point but are characterized by a distribution of failures over a temperature interval. The improved brittleness tester makes it possible to carry out the necessary statistical study of the distribution of per cent failures *versus* temperature with a reasonable amount of work. A simple analysis of the resulting distribution curve is presented.

THE need for a test that will predict the behavior of elastomers at low temperatures has already been discussed by Selker, Winspear, and Kemp³ and others.^{4,5} They also developed a method and equipment for obtaining the temperature at which elastomers become brittle. This temperature was defined as the lowest temperature at which the material could withstand sudden deformation (bending) under specified conditions without breaking. It was found that this temperature was dependent upon the maximum strain (radius of curvature of the bend) and the rate of straining (velocity of impact). It was also found that some materials such as natural rubber had a very sharp brittle point while for other elastomers a temperature range was found in which both failures and nonfailures occurred. Therefore, the brittleness temperature was defined as the lowest temperature at which five successive specimens remained unbroken.

On the basis of the work done by these investigators a tentative method of test was adopted by the A.S.T.M. (D 746 - 44 T).² The equipment suggested in the tentative method tested only one specimen at a time. This is very time-consuming since each specimen must be cooled at least two minutes prior to testing and several test specimens must be run to locate the brittleness temperature. This temperature then must be confirmed by at least five additional tests. In addition, it

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

¹ Development Laboratories, Bakelite Corp., Bound Brook, N. J.

² Tentative Method of Test for Brittle Temperature of Plastics and Elastomers (D 746-44 T), 1946 Book of A.S.T.M. Standards, Part III-B, p. 817.

³ M. L. Selker, G. G. Winspear, and A. R. Kemp, "Brittle Point of Rubber Upon Freezing," *Industrial and Engineering Chemistry*, Vol. 34, p. 157 (1942).

⁴ A. R. Kemp, F. S. Malm, and G. G. Winspear, "Brittle Temperature of Rubber Under Variable Stress," *Industrial and Engineering Chemistry*, Vol. 35, p. 488 (1943).

⁵ R. F. Clash, Jr., and R. M. Berg, "Stiffness and Brittleness of Nonrigid Vinyl Chloride-Acetate Resin Compounds," *Modern Plastics*, Vol. 21, p. 119 (1944).

was found that for some materials the region in which both failures and nonfailures occurred was very wide (as much as 40 C.); hence the brittleness temperature might vary widely from test to test in spite of the criterion of five successive nonfailures. The width of this temperature interval and the distribution of the percentage of failures and nonfailures are important characteristics of the low-temperature brittleness of a material.

It is evident that brittleness testing with a one-specimen machine is highly time-consuming even for materials of sharp brittle point. Such a machine becomes totally inadequate whenever the brittleness characteristics must be determined by a statistical analysis of failures and nonfailures. To meet this need, an improved five-specimen tester was designed and a simple method of statistical analysis developed.

APPARATUS

Figure 1 is a photograph of the interior of the improved tester showing the specimens in place and the striking arm about halfway through its travel. The bath is empty but it is normally filled with coolant to about one inch

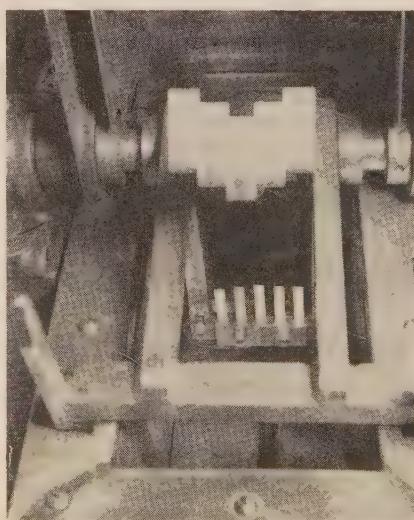


Fig. 1.—Interior of Brittleness Tester.



Fig. 2.—High-Speed Motion Pictures Used to Measure the Velocity of Striking Arm.

above the specimens. A stirrer located in the rear is obscured by the striker. Also in the rear is a heater for raising the temperature rapidly. This part of the tester is essentially the same as that suggested in A.S.T.M. Method D 746 except that five specimens are tested instead of one. The specimens are held in the coolant for at least 2 min. and then bent by the striking arm through an angle of approximately 90 deg. The velocity of the striking arm is specified as 6.5 ± 0.5 ft. per sec. The clearance between the specimen clamp and the striking head is $\frac{1}{4}$ in. (A.S.T.M. Method D 746 - 44 T). To facilitate changing specimens the holder is pivoted about the striking arm shaft. To change specimens it is swung out of the bath (see Fig. 4), the clamp is removed and is then replaced with one containing new specimens.

Since the brittle temperature is dependent upon the maximum strain and rate of straining, machine clearances and specimen thickness must be accurately controlled and the velocity of the impact must be unaffected by bending the specimens. To maintain the velocity of the striking arm constant, sufficient

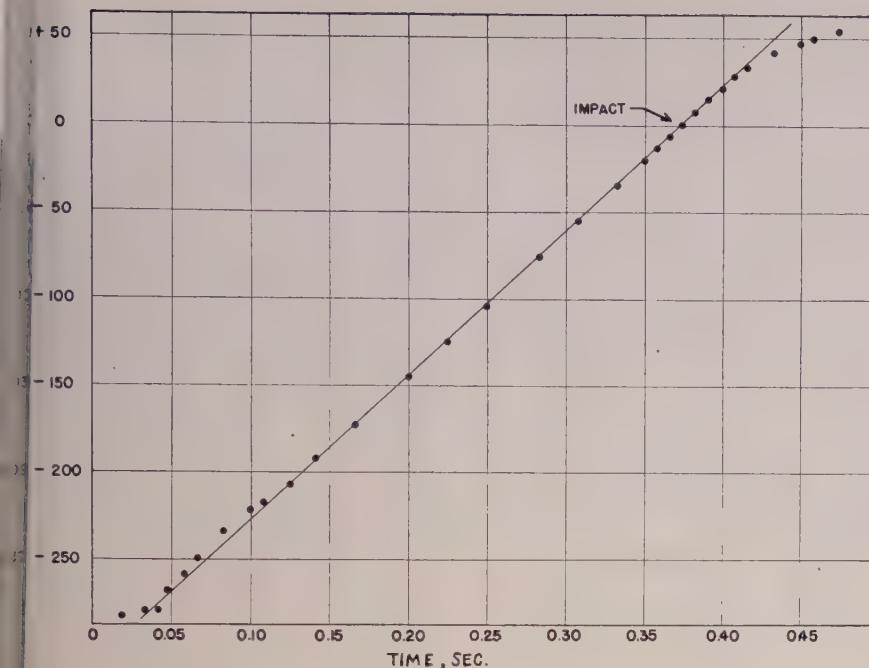


Fig. 3.—Angular Displacement of Striker *versus* Time in Seconds During a Brittleness Test.

nergy is supplied by attaching a flywheel to a $\frac{1}{2}$ -hp. motor. The motor and flywheel run continuously. To perform a test, the striking arm is engaged by a specially designed clutch, turned one revolution and arrested.

The motion of the striking arm under actual test conditions was studied by means of high-speed motion pictures (4000 frames per second) taken at the Bell Telephone Laboratories with a Western Electric "Fastax" camera. Figure 2 shows three consecutive frames of one of these films. In the lower left-hand corner is the timer, a disk, graduated in 10 deg. intervals, attached to the shaft of a synchronous motor rotating at 1800 rpm. The disk in the center is attached to the striking arm shaft and above is a reference mark on the frame of the tester.

Figure 3 is a plot of the angular displacement of the shaft *versus* time in seconds. It shows that a slight rebound occurs as the clutch engages the striker, but the velocity is constant before, during, and after impact. From the slope of the line the velocity is computed to be 6.6 ft. per sec. Pictures were taken under various test conditions with identical results.

Figure 4 is a picture of the complete unit as designed by H. A. Swallow and J. P. Shook of the Bakelite Development Laboratories and built to their specifications by Accurate Tool Co., Newark, N. J.

The clutch is operated by turning the handle to the right of the tank 90 deg. in a clockwise direction. A safety device makes it impossible to operate the

clutch unless the specimens are in place, and the splash cover closed and latched.

Acetone and ethyl alcohol or liquid "Freon" are used in the bath, and dry ice or liquid nitrogen as the refrigerant. The unit has given trouble-free operation at temperatures as low as -130°C .

RESULTS AND DISCUSSION

The advantages of this machine can perhaps be best illustrated by the low-temperature behavior of a typical polyethylene. It was found that reliable data could be obtained only by a statistical study of failures as a function of temperature. Ten to 30 specimens had to be broken at a given temperature in

order to obtain a picture of the brittle temperature distribution. The results are shown in Fig. 5, as per cent failures *versus* temperature distribution curve. The temperature spread from complete failure to complete nonfailure is so wide (about 40°C) that the brittle temperature of polyethylene can be defined only in terms of an arbitrary point along the distribution curve, say, T_{50} , corresponding to 50 per cent failure.

The curve of Fig. 5 suggests an exponential behavior. Replotting in terms of $\log(\text{per cent failure})$ *versus* temperature results in a straight line as shown in Fig. 6. Such a semilog plot, since it is linear, permits averaging of the experimental points and is very convenient for a precise determination of the 50 per cent breakage point. The brittle temperature distribution for polyethylene may, therefore, be represented by the equation

$$n = Ae^{-\alpha T} \dots \dots \dots (1)$$

where:

n = per cent failures,
 T = temperature in degrees absolute, and
 A and α = constants.

Since the line must stop at 100 per cent failures, Eq. 1, of course, has no meaning at temperatures below this point. The constant α , which is calculable from the slope of the semilog plot by

$$\alpha = -2.3 \times \text{slope} \dots \dots \dots (2)$$

is a measure of the sharpness or width of the transition interval. A large value of α means that the transition interval is narrow while small values of α characterize a distribution curve which is spread over a wide temperature range.

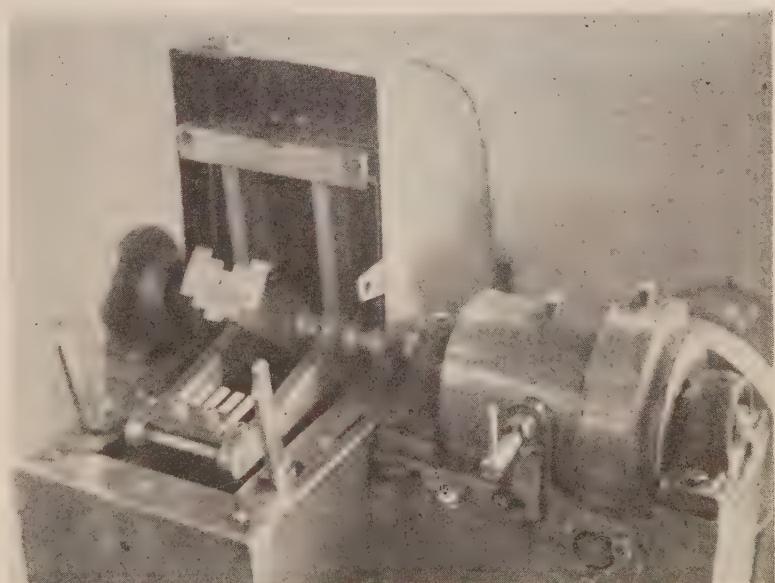


Fig. 4.—The Brittleness Tester.

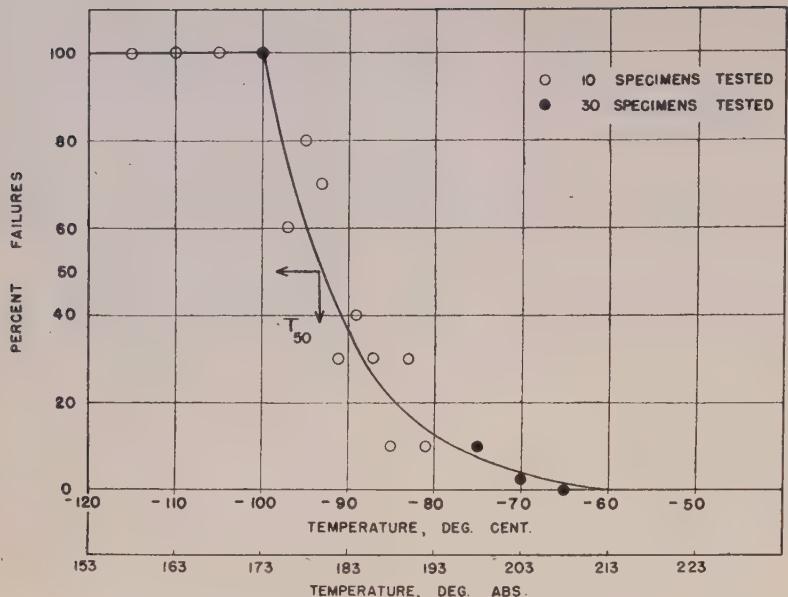


Fig. 5.—Per Cent Failures Distribution *versus* Temperature Curve for Polyethylene Resin DYNH.

TABLE I.

Material	Brittle Temperature at 50 Per Cent Breakage, T_{50} , deg. Cent.	Sharpness of Transition Interval, α
Polyethylene, DYNH.....	-93	0.11
VG-9531.....	-2.5	0.21
"Vinylite" VYNW + 35% DOP.....	-32.5	0.29
"Vinylite" VYNW + 45% DOP.....	-44.2	0.34
Neoprene.....	-35.7	Approx. 1.8
Hycar.....	-19.5	Approx. 0.7

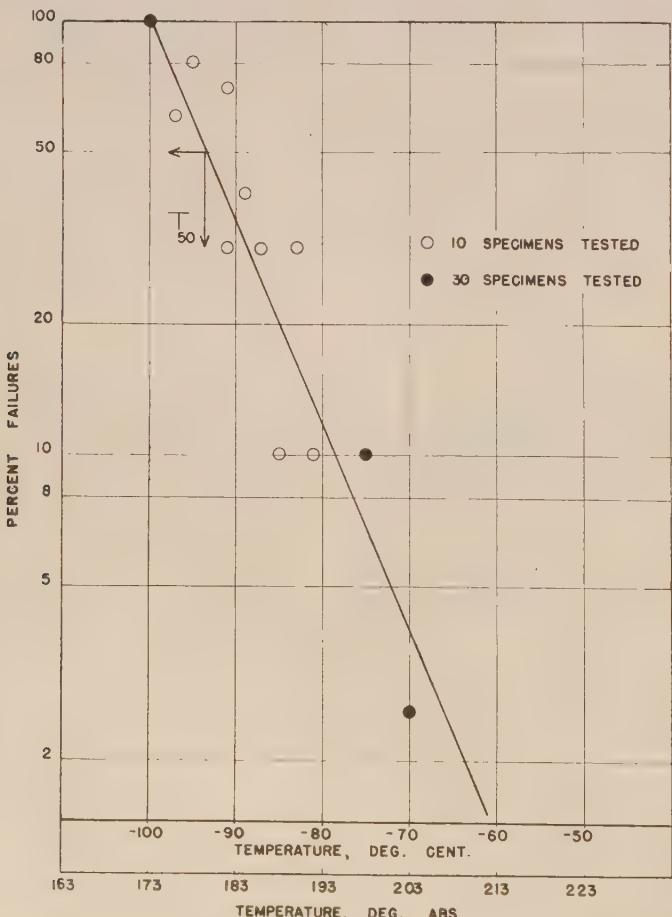


Fig. 6.—Log Per Cent Failure *versus* Temperature Curve for Data of Fig. 5.

Thus, a statistical study not only defines a brittle point, T_{50} , which has a definite and clear-cut meaning but also furnishes further information about the material under test, namely, the width of its brittle temperature interval. It is recognized that for materials which are characterized by a narrow brittleness distribution, the brittle temperature T_{50} is very near the temperature at which no specimens fail. This is evidently not the case for such materials as polyethylene. Because of the nature of the distribution curves (see Figs. 5 and 6), which approach the no failure line very gradually, extrapolation to zero per cent failure is impractical. However, for purposes of comparison, it may be useful to specify also T_1 , that is, the temperature at 1 per cent failure, as an index of brittle temperature.

"Vinylite"⁶ compounds also show a transition interval which, however, is considerably narrower than that for polyethylene. In Figs. 7 and 8 data are presented for two plasticized "Vinylite" VYNW compounds and for a "Vinylite" wire insulation compound, VG-9531. Again the exponential representation is found to be very satisfactory (Fig. 8) although the distribution curves are considerably sharper. Figure 7 also shows the results for two synthetic rubber compounds. The transition interval is narrow enough in the case of the rubbers to dispense with the statistical method for routine testing. Fifteen specimens were tested at each temperature in determining these curves.

It is of interest to compare, numerically, the brittle temperature properties of the above compounds as shown in Table I.

These examples illustrate the necessity of carrying out a statistical study of the brittle temperature properties of any new elastomer. The statistical method cannot be dispensed with even in routine testing unless the transition interval is very narrow, represented by a large α —possibly greater than 0.5. The type of instrument described here makes it possible to obtain the necessary data for a statistical analysis with a reasonable amount of work.

Acknowledgment:

The cooperation of I. L. Hopkins, J. B. DeCoste, and F. M. Tylee of the Bell Telephone Labs. in obtaining the high-speed photographs is greatly appreciated. The authors are indebted to their associates at the Development Laboratories of the Bakelite Corp. for assistance during the course of this work. It is a pleasure to acknowledge the extensive cooperation of R. A. deCoudres, E. F. Schulz, R. C. Boyd, A. P. Wangsgard, and R. F. Clash, Jr.

⁶ Registered trade-mark.

DISCUSSION

Mr. Robert Burns.¹—Discussing a technical paper is a dangerous business. If we say the paper is perfect the discusser is immediately branded as a faker, and if we say it ain't the authors are offended. But the human desire to be a kibitzer transcends all other considerations. Where is the scientist who hasn't said, "Oh, Oh! Don't do that! Your partner led with his Fahrenheit, you're supposed to take the trick with your Maximum Fiber Stress."

There is complete agreement that Messrs. Smith and Dienes have done us all a favor by constructing the five-holer brittleness tester. (The track record is still held by the Brooklyn Navy Yard with its eight-holer heat distortion tester.—ED.) The unmitigated curse of our profession is the fellow who walks into the laboratory with two grams of material in his inspiring hand and demands complete physical and chemical evaluation. Smith and Dienes are to be congratulated for making it clear that if you are really sincere in wanting to determine low-temperature brittleness you'd better come prepared with a fistful of specimens.

It is always disappointing to learn that our plastics are not jewels of consistency but are veritable flutterbudgets dropping their data like unrestrained flyspecks on an unsuspecting sheet of rectilinear paper. The authors present persuasive evidence that the brittle point of polyethylene is not a point at all but a phenomenon spread over a wide range of temperatures, indeed wider than for certain other nonrigids. But undaunted by their own data they insist upon establishing a point, even if it kills them, and it almost does before they get through rassling with their statistical studies.

One may argue about statistics, about the empirical nature of the test, about the constancy or inconstancy of polyethylene; the fact remains that Smith and Dienes have built a device which will shorten the testing time in the case of those materials which may have a precise brittle point for a standardized combination of testing conditions, and permit exploration of those which do not.

Until more information is at hand we should discourage the concept of brittle point as a fundamental property comparable to melting point, modulus of elasticity, or dielectric constant. The machine under discussion should go a long way toward clarifying the situation.

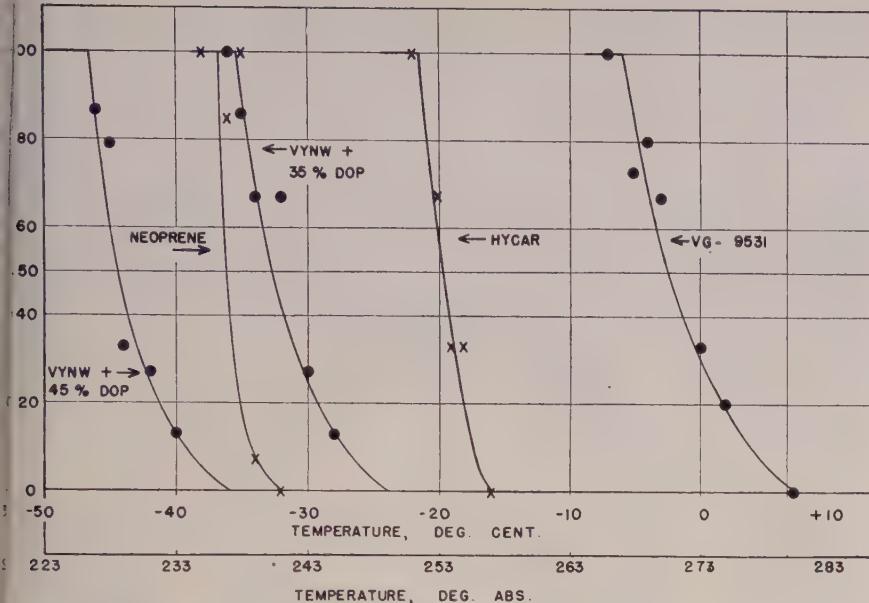


Fig. 7.—Per Cent Failure Distribution *versus* Temperature Curves for Various Elastomers.

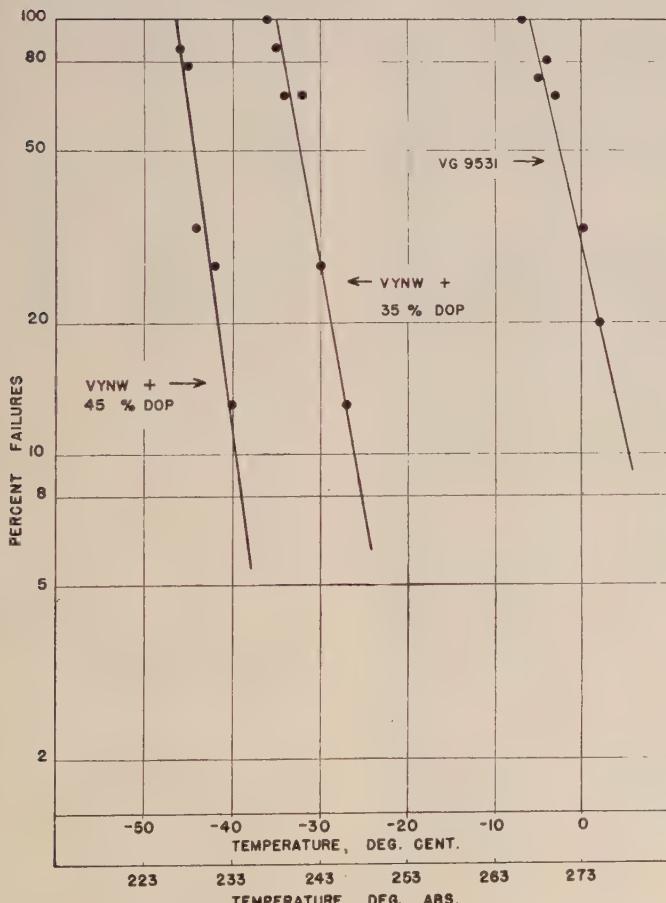


Fig. 8.—Log of Per Cent Failure *versus* Temperature Curves of Three "Vinylite" Compounds.

¹ Bell Telephone Laboratories, New York, N. Y.

Dynamic Calibration Method Uses Modified Proving Ring

By R. C. A. Thurston²

VARIOUS satisfactory methods of calibrating direct stress fatigue machines by means of bonded resistance wire strain gages have been described in the technical literature. Although instrumentation and technique may appear complicated, they are simple to the average electrical engineer. However, for the mechanical engineer the method described here, with a slight sacrifice of accuracy, is considered advantageous.

This method employs a modified Morehouse proving ring to measure dynamic load. The ring is modified by replacing the vibrating reed with a spring-loaded plunger having double electrical contacts for indicating purposes only. This permits measuring both maximum and minimum load in tension or compression. Previously, only the maximum load in pulsating compression or the minimum load in pulsating tension could be calibrated.

The Morehouse proving ring, shown in Fig. 1, is an elastic steel ring, designed primarily for determining static loads by micrometer measurement of the ring's deflection. Rings of less than 110,000-lb. capacity are carefully calibrated in a precision dead-weight machine by the National Bureau of Standards, Washington, D. C. A calibration factor, varying with deflection, is then supplied for tension and compression, together with a temperature correction factor. The calibration factor remains constant several years with normal care.

The unmodified ring can be used directly for dynamic calibration, but the value of the reed as an indicator is considerably reduced, and errors may be appreciable at certain critical testing speeds. Sonntag Scientific Corp. first overcame this difficulty by replacing the reed with an electrically insulated, spring-loaded plunger having a single indicator contact. When the anvil of the micrometer screw contacts the lower end of the plunger, a circuit is completed and a neon lamp glows.

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¹ Published by permission of the Director, Mines, Forests and Scientific Services Branch, Department of Mines and Resources, Ottawa, Canada.

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³ The boldface numbers in parentheses refer to the list of references appended to this paper.

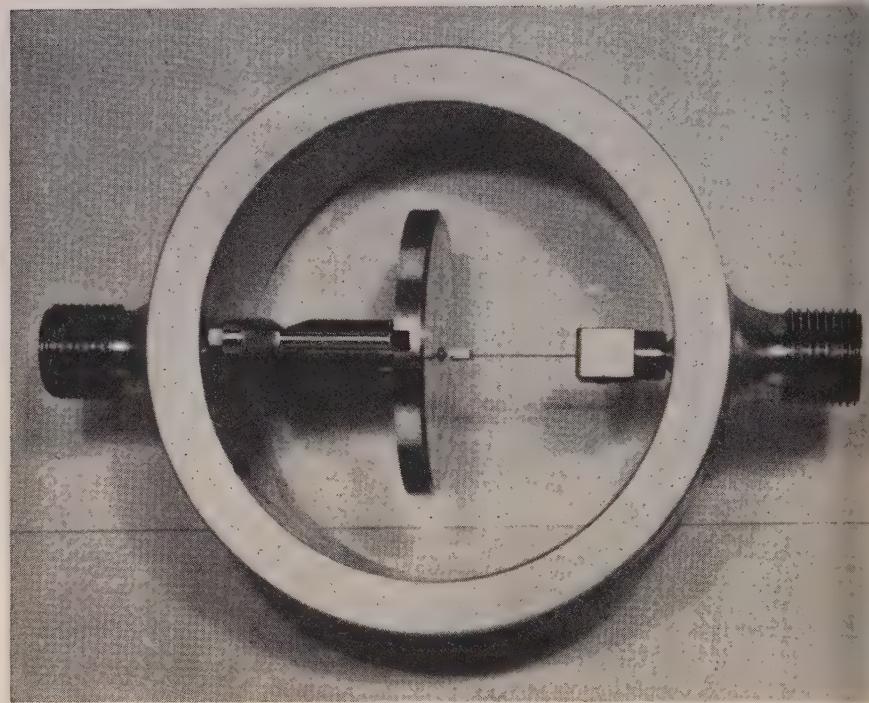


Fig. 1.—50,000-Lb. Morehouse Proving Ring.

CALIBRATION OF SONNTAG MACHINE

This modified ring was first utilized on a 20,000-lb. Sonntag fatigue machine (1).³ The machine, shown in Fig. 2, is a direct-stress fatigue machine of the resonance type. It has a preload capacity of $\pm 10,000$ lb. (tension or compression) and a dynamic load range of 20,000 lb., the testing speed varying from 1200 to 1900 rpm. The static load is determined by the deflection of the springs. The dynamic load is measured and controlled through an SR-4 dynamometer, consisting of a steel tube with SR-4 bonded resistance wire strain gages attached, mounted in series with the test specimen.

A dynamic calibration was carried out in compression, using a 50,000-lb. modified ring with a single indicating contact. A preload of 10,000 lb. was applied, and proving ring readings were taken for a number of superimposed load ranges. Static readings, corresponding to the preload, were recorded before and after the application of each separate dynamic range and were constant to ± 0.5 division (37 lb.). The micrometer setting, under dynamic load, as indicated by the flashing of the neon lamp, was fairly critical. This is borne out by the results of two successive calibrations which agreed to within ± 0.5 division.

FURTHER DEVELOPMENT

In the above tests the modified proving ring can only be used to measure either the maximum load (in compression) or the minimum load (in tension) but not both loads in tension or compression. A 50,000-lb. ring was further modified, therefore, as shown in Fig. 3, to accomplish this by means of a double contact arrangement.

A U-shaped contact piece was attached to the lower end of the spring-loaded plunger, with a small thrust bearing behind it to facilitate rotation. A single contact spring was then clamped in a block fastened to the micrometer disk and positioned so the contact was made on the vertical loading axis of the ring. The rest of the arrangement was similar to that in the Sonntag modification, including the neon lamp as an indicator.

The re-modified ring was first checked statically in compression in a recently calibrated Amsler machine. It was found possible to repeat the ring readings for any load within ± 0.5 division (31.5 lb.), provided care was taken to maintain clean contacts. The results of three test runs were in good agreement with the previous calibration, the maximum error being 0.3 per cent.

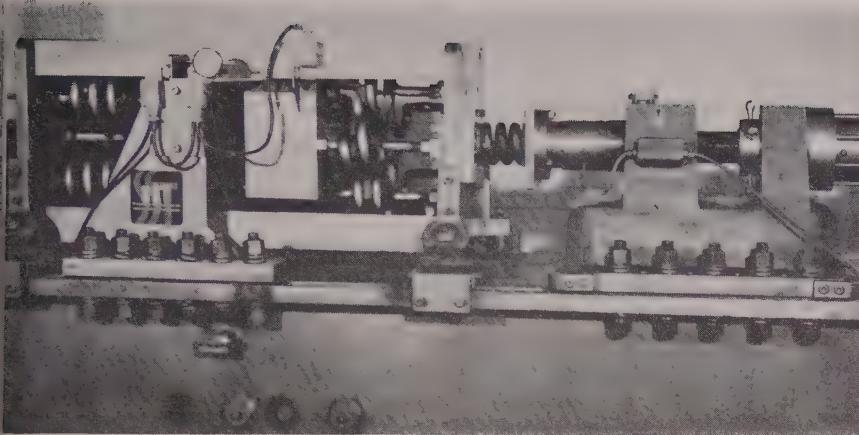


Fig. 2.—20,000-Lb. Sonntag Direct Stress Fatigue Machine. Helical Spring Test.

CALIBRATION OF AVERY MACHINE

The 20-ton Avery machine (2) was calibrated similarly. This machine, shown in Fig. 4, is another direct-stress fatigue machine of the resonance type. It has a preload capacity of 10 long tons (tension or compression) and a dynamic load range of 20 long tons. The testing speed varies from 2600 to 2900 rpm. Static and dynamic loads are measured by means of a ring-type dynamometer in series with the test specimen. The deflection of this dynamometer is determined by means of a microscope having a graduated eyepiece and an illuminated slit.

The static calibration of the machine was carried out in tension in the normal way, using an unmodified 50,000-lb. ring. The relationship between the applied load P (in kilopounds) and the static dynamometer deflection X_p (in scale divisions) was not truly linear, but could be expressed, within the limits of experimental accuracy, as a parabola:

$$X_p = 2.88P + 0.007P^2 \dots \dots (1)$$

The dynamic calibration was then performed, also in tension, using the modified ring. A preload of 10,000 lb. was applied, and micrometer readings were taken at both contact positions. The machine was started, and similar double readings were taken at selected values of dynamic load range, together with the corresponding microscope readings of dynamometer deflection. The ring was carefully maintained in tension. This procedure was repeated with tension preloads of 8000, 6000, and 4000 lb., and finally the complete series of tests was repeated.

The results were analyzed on the basis of the parabolic relationship, which leads to the following equation for dynamic dynamometer deflection, X (in divisions), in terms of load range R (in kilopounds):

$$X = (2.88 + 0.014M)R \dots \dots (2)$$

where M = preload in kilopounds.

The true microscope band-width was plotted against the load range for each of the various preloads, and the best-fitting straight lines were drawn. The equations of the lines were found, and from these the following relationship was derived:

$$X = (2.88 + 0.022M)R - 0.1M \dots \dots (3)$$

The presence of the term $0.1M$ was somewhat unexpected, although a similar result had previously been obtained in calibrating another machine of this type by a different method. The cause may be some defect in the optical system. The equivalent static calibration, neglecting this term, is given by:

$$X_p = 2.82P + 0.011P^2 \dots \dots (4)$$

Deflection readings calculated from this expression agree to about 1 per cent, up to 20,000-lb. load, with those ob-

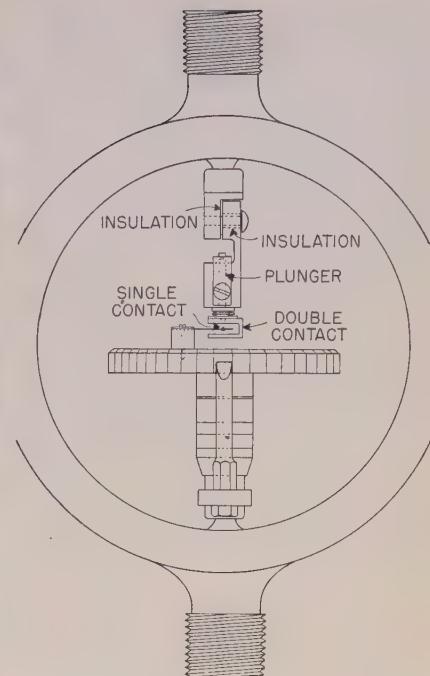


Fig. 3.—Modification of Proving Ring for Dynamic Calibration.

tained from the static calibration. This agreement is considered to be satisfactory.

GENERAL OBSERVATIONS

The Morehouse proving ring was designed primarily to measure static loads. The nominal working stress, computed from Timoshenko's equations, for the capacity load of 50,000 lb. on this particular ring, was about 145,000 psi. According to Wilson, Tate, and Borkowski (3), computed working

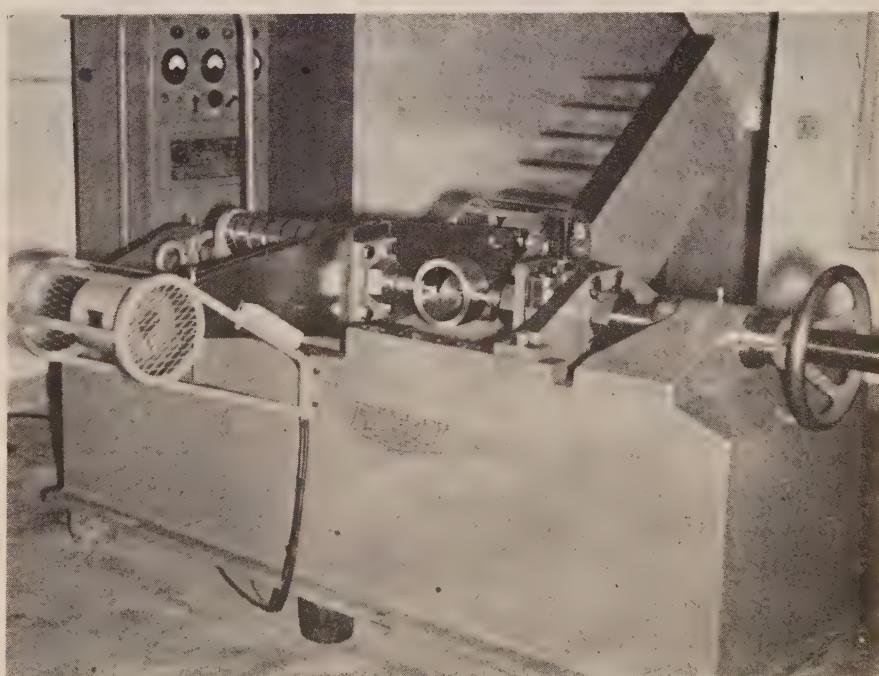


Fig. 4.—20-Ton Avery Direct Stress Fatigue Machine with Proving Ring for Static Calibration.

stresses as high as 150,000 to 165,000 psi. have been satisfactory. Under dynamic loading conditions, it was considered inadvisable to load the ring above about half its capacity. In the tests described the load range was limited to 20,000 lb.

One possible cause of error in the modified ring is superimposed vibration of the spring contact mounted on the micrometer disk. The natural frequency of transverse vibration of this spring was about 4800 cycles per sec., which is well outside the frequency range of the fatigue machine. During calibration the ring was illuminated by a Strobotac, flashing at the running frequency, and no movement of the spring contact could be observed. An improvement in the design, however, would be to mount the hemispherical

contact points on the U-shaped piece and thus eliminate the possibility of spring movement by inertia forces.

The work of Wilson and Johnson (4) in this field is also interesting. In their adaptation of a 25,000-lb. ring, the micrometer and reed were replaced by an adjustable screw and an electrical contact, with a neon glow lamp as indicator. The modified ring was used with photographic recording, to compare static and dynamic loads in universal testing machines for different rates of loading up to approximately 50,000 lb. per min. The sensitivity of this device, when tested by dead-weight loading, was found to be less than 2 lb.

It has been possible to give here only a brief outline of the developments in the use of proving rings for dynamic purposes. It is hoped, however, that

sufficient has been given to indicate the possible scope of applications.

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The Action of "Chromic Acid" on Zinc Coatings

By D. J. Swaine¹

DURING a recent investigation of some old galvanized sheets and wires, Anderson and Reinhard's method² of removing corrosion products was used. This method was tested initially on specimens of pure zinc, new galvanized sheet, and new galvanized wire.

A piece of electrolytic zinc, which had been rolled, was treated with 2 N hydrochloric acid, washed with water, dried with a cloth, left in a desiccator for two and a half days and weighed. Samples of new galvanized sheet and fencing wire were cleaned with benzene, left in a desiccator for two and a half days and weighed. Analytical data for these samples are as follows:

	Iron, per cent	Lead, per cent	Tin, per cent	Cadmium, per cent
Electrolytic zinc.....	0.007	0.07	...	0.07
Galvanized sheet (coating)....	3.0	0.90	0.30	...
Galvanized wire (coating)....	6.5	0.5	...	...

Tests were carried out by immersing the specimens for 1 min. in a "chromic acid" solution (200 g. CrO₃ per liter) at 80°C. The specimens were then washed well with water, dried thoroughly with a cloth, left in a desiccator for 20 hr. and reweighed. Since the presence of appreciable amounts of sulfates and chlorides in the "chromic acid" solution would aid, rather than prevent, attack of the zinc, the CrO₃ used was analyzed.³

It contained 0.016 per cent sulfate and less than 0.005 per cent chloride.

The results of repeated immersion tests are as follows:

Surface Area of Specimen, sq. cm..	Loss in Weight, g. per 100 sq. cm.		
	Electrolytic Zinc	Galvanized Sheet	Galvanized Wire
	68.2	61.2	38.5
After first dip.....	0.0151	0.0161	0.0117
After second dip.....	0.0009	0.0026	0.0039
After third dip.....	0.0034	0.0013	0.0026
After fourth dip.....	0.0007	0.0015	0.0013
After fifth dip.....	0.0000	0.0010	0.0013
After sixth dip.....	0.0006	0.0013	...
After seventh dip.....	0.0018	0.0021	...
Average loss per dip.	0.0032	0.0037	0.0042

It will be noticed that the initial immersion caused a relatively high loss in weight. However, an average loss in weight per dip has been calculated and could be used as a correction. Anderson and Reinhard² give values of 0.0002 g. per 100 sq. cm. for pure zinc and 0.0011 g. per 100 sq. cm. for commercial zinc in the soft, hot-rolled state. Since the conditions of my tests were probably different from those of Anderson and Reinhard's, no direct comparisons can be made.

It is suggested that the loss in weight of a zinc specimen treated with the "chromic acid" solution depends on the state of the zinc surface, the purity of the zinc, and the purity of the "chromic acid" solution. In any case the amount of zinc removed is fairly small compared with the amount of zinc in the coating of sheets and wires, and hence the use of this method for removing corrosive products from weathered galvanized articles is allowable.

SUMMARY

Results of the action of hot "chromic acid" on electrolytic zinc, galvanized sheet and galvanized wire are tabulated. The losses in weight are small enough to warrant continued use of this reagent for the removal of corrosion products from galvanized articles.

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¹ Chemistry Department, The University of Melbourne, Victoria, Australia.

² E. A. Anderson and C. E. Reinhard, *Proceedings, Am. Soc. Testing Mats.*, Vol. 39, p. 691 (1939).

³ J. Rosin, "Reagent Chemicals and Standards," D. Van Nostrand & Co., Inc., New York, N. Y., p. 134 (1946).

Better Lead Scavenging Needed for Aviation Gasoline

By E. A. Droegemueller¹

THE great drawback to the use of tetraethyl lead in aviation gasoline is its propensity for leaving harmful deposits in the engine. This handicap has been recognized since the first use of lead as an antiknock agent, and a scavenging agent is added in order to decrease the lead residues left in the engine. The purpose of this paper is to review the performance of the present scavenging agent and report tests made by Pratt and Whitney Aircraft on a proposal to improve scavenging by using 5 times the usual amount of the present agent.

The antiknock mixture now used in aviation gasoline contains ethylene bromide as the lead-scavenging agent, the amount added to the mixture being at theoretically just sufficient to convert all the lead to lead bromide during combustion of the fuel-air mixture. This reduces the amount of the deposits, but it is not completely effective. Even if the proportion of tetraethyl lead is only $\frac{1}{600}$ by weight, an engine averaging 1200 hp. for 1000 hr. will have something like $\frac{1}{2}$ ton of metallic lead supplied to it in the fuel, and even a very small part of this left behind in the cylinders will be sure to make trouble.

Recent tests with more ethylene dibromide, 1.5 times the amount presently used in aviation gasoline, demonstrated that scavenging was indeed better; less of the lead was left as deposits, and the engine and spark plugs were comparatively clean. Unfortunately, a substantial penalty in the form of corrosion went along with this improvement. Bromine which escapes combining with the lead, produces corrosive liquids, such as hydrobromic acid. The corrosion was so great that it was very evident that this is not the cure to the deposit problem we are looking for. What is needed is a better scavenger with less of the drawbacks now possessed by the present one.

Need for Better Scavenging Agent:

One critical difficulty is spark plug fouling which occurs where the engine conditions for maximum range are used, namely, low power, low engine speed, high altitude, lean mixture, especially

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¹ Pratt and Whitney Aircraft, Division of United Aircraft Corp., East Hartford, Conn.

² E. A. Droegemueller, "Cutting Aircraft Engine Maintenance Cost," *ASTM BULLETIN*, No. 148, October, 1947, p. 79.

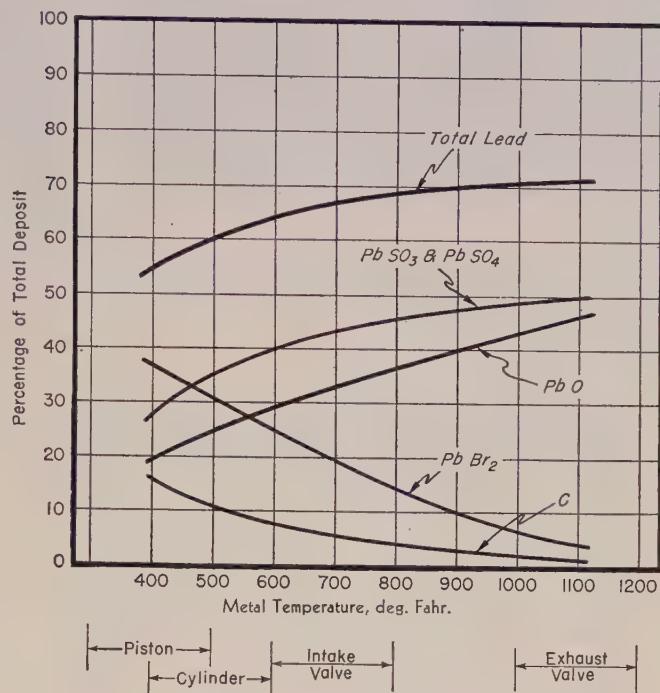


Fig. 1.—Chemical Analysis of Combustion Chamber Deposits.

where these conditions are maintained over a long period of time.

An improved scavenging agent for lead residues is needed to give relief from some of the troubles of the airline operators. Flight delays and maintenance expense due to ignition troubles come at the top of the list. Statistics show that spark plugs have caused a greater amount of trouble than any other airplane unit, accounting for 6.35 per cent of total unscheduled unit removals, 10 per cent of mechanical delays and for 12.3 per cent of flight interruptions.

This trouble should not be blamed on the spark plug manufacturers, since lead fouling is the usual cause of plug changes. Other service problems such as piston burning, intake valve stretching, valve guide corrosion, and sludge carried by the oil throughout the engine resulting in stuck clutches, collapsed oil screens, and a generally dirty engine, are chargeable to the lead residues from the fuel.² There is abundant proof that the severity of these troubles is influenced by the amount of lead in the fuel. Actual service records from two comparable airlines allow an interesting comparison on this point. One airline operates on fuel averaging 4.4 ml. of tetraethyl lead per gallon. This airline averages 175 unscheduled spark plug removals per 10,000 operating hours and

4.65 premature engine removals in the same period. The other airline uses fuel which averages 2.4 ml. of tetraethyl lead per gallon. Their records show 60 unscheduled spark plug removals and 1.33 premature engine removals in a comparable period. Thus a 43 per cent reduction in the lead content is accompanied by a 66 per cent reduction in unscheduled spark plug removals and a 71 per cent reduction in premature engine removals.

The quantity of potential deposit-forming materials supplied in present aviation gasolines is staggering. The relatively nonvolatile material contained in the fuel used by a typical engine in airline operation, during its normal period of time between overhaul (roughly 100,000 gal.), is as follows:

TABLE I.—DEPOSIT-FORMING MATERIAL SUPPLIED PER 1000 HR.

Component	Concentration ^a	Material Supplied, lb.
Metallic lead.	4.6 ml. TEL per gal.	1000
Sulfur.....	0.05 per cent by weight	300
Gum.....	6 mg. per 100 ml.	50
Inhibitor....	1 lb. per 5000 gal.	20
Dye.....	14 mg. per gal.	3

^a Maximum permitted by specifications.

It is obvious that the fuel, although it would meet existing specifications, contains more than enough relatively

nonvolatile material to cause operating difficulties if conditions conducive to deposit formation prevail. An accumulation of considerably less than 1 lb. of deposit in the induction system of the engine may reduce power by 50 to 100 hp.

The dye is added to the fuel merely to warn that it contains lead. The inhibitor is added to stabilize the lead and safeguard the fuel from the formation of gum during storage. The ethylene dibromide is added to scavenge the lead from the engine.

Method of Scavenging Lead:

The present approach to the deposit problem is the introduction of a naphtha soluble halide to combine with the lead and form volatile inorganic salts. Both antiknock mixture manufacturers, E. I. du Pont de Nemours and Co. and the Ethyl Corp. add ethylene dibromide to aviation fuels as a lead-scavenging agent, using two atoms of bromine per atom of lead or the amount of ethylene dibromide which would theoretically convert all the lead to the comparatively volatile lead bromide. This mixture is called 1-T (1-theory) fluid. Not all the lead is converted to lead bromide, nor is lead bromide volatile enough to be entirely displaced from the cooler metal surfaces as evidenced by chemical analysis of combustion chamber deposits from various parts of the chamber. This is shown in Fig. 1.

Table II contains handbook data on lead compounds that are present in combustion chamber deposits.

TABLE II.—PROPERTIES OF SOME LEAD COMPOUNDS.

Compound	Color	Melting Point, deg. Fahr.
PbO.....	Yellow to red	1630
PbSO ₄	White	1830 to 2000
PbBr ₂	Brown-white	700
PbO-PbBr ₂	White	622 to 1634
PbCl ₂	White	930
PbO-PbSO ₄	White	1790

We have done very little work thus far in the identification of the molecular form of lead compounds, our deposit compositions being calculated from solubility analyses and ultimate analysis, particularly the latter. There is evidence, however, that all of the lead is not tied up as PbO, PbSO₄, and lead halides, but that certain complex salts are also formed.

To perform the scavenging function, the right amount of dibromide must follow the lead into the engine cylinder. In some engines with long manifolds, it is difficult to get this distribution, especially since the dibromide is more volatile than the tetraethyl lead. If the fuel, the bromide, and the lead have the same vapor pressure, better distribution would be expected. The present situa-

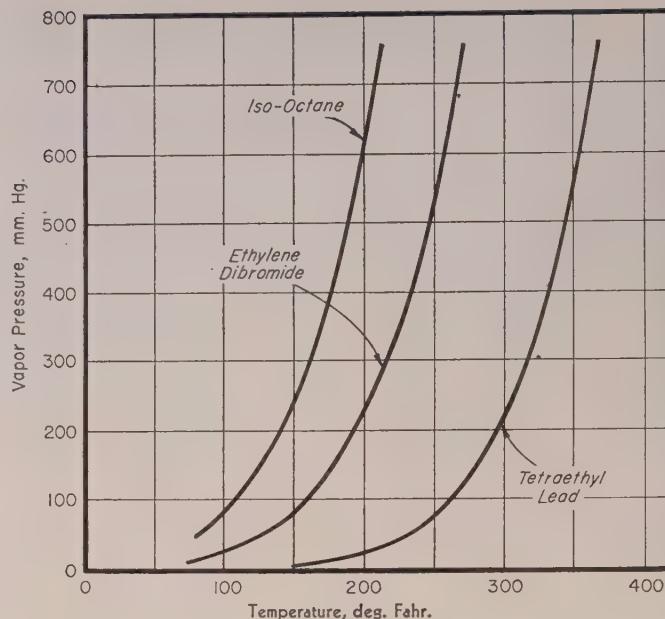


Fig. 2.—Vapor Pressure Chart.

tion is shown on the vapor pressure chart of Fig. 2. The use of tetramethyl lead has been suggested since it has a vapor pressure approximating that of the fuel.

Tests in line-type engines with an excess of ethylene dibromide showed some reduction in deposits, and the Ethyl Corp. suggested that this be tried on radial engines. Pratt and Whitney Aircraft had run some tests in 1940 and 1941 on fuel containing 1.5-T fluid, but these were primarily fuel volatility tests, and the lead content of the fuel was not over 3 ml. per gal. The test conditions were not chosen to accentuate spark plug fouling and combustion chamber deposits, and it was felt that these early tests gave little reliable information about the effect of 1.5-T fluid.

Recent Tests:

In order to make conclusive tests of fuel containing an overdose of ethylene dibromide, three endurance tests were run on R-2800 multicylinder engines. The program for each test was set up to simulate typical flight schedules of a DC-6 airplane. This included "flights" of various durations, and each "flight" was complete in itself with appropriate warm-up, take-off, climb, cruise, descent, approach, and taxi periods. The differences between the three tests were as shown in Table III.

TABLE III.—ENDURANCE TESTS.

Test	Engine	Time, hr.	Fuel
I...	R-2800	500	Grade 115/145 with 4.6 ml. TEL 1.0-T fluid
II...	R-2800	300	Grade 115/145 with 4.6 ml. TEL 1.5-T fluid
III...	R-2800	185	Grade 100/130 with 4.6 ml. TEL 1.5-T fluid

Test I was operated on the present fluid (1-T fluid) to establish a basis for comparisons. The results of tests II and III, on 1.5-T fluid, were the same; the same troubles appeared in each adding weight to the conclusions drawn from them. The composition of 1.0-T and 1.5-T fluids are compared in Table IV.

TABLE IV.—DATA ON TETRAETHYL LEAD MIXTURES.

Weight per cent composition:	Components	
	Tetraethyl lead	Ethylene dibromide
	Boiling point, deg. Fahr.	269
Density, g. per ml.	1.659	2.18
Molecular weight	323.5	187.9
Mixtures		
1-T Fluid	1.5-T Fluid	
	Tetraethyl lead	52
Ethylene dibromide	36	45
Dye, impurities, etc.	3	3
Volume per cent composition:		
	Tetraethyl lead	57
Ethylene dibromide	28	37
Dye, impurities, etc.	7	6
Lead content, per cent	39	33
Bromine content, per cent	30	39
Specific gravity at 20 C.	1.746	1.801

Distribution:

Previous testing of this type has been done mostly on line-type engines which have suffered from maldistribution of the fuel, dibromide, and lead and have had extremely bad spark plug fouling concentrated in two or three cylinders. The radial engines with which we are familiar do not suffer from this distribution trouble, as shown by the very low specific fuel consumption obtainable (approximately that of single cylinder), and the fact that spark plug fouling and other troubles are not concentrated in any one or a few cylinders.

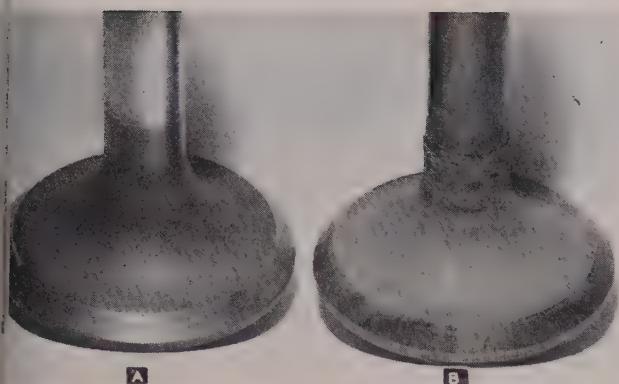


Fig. 3.—R-2800 Exhaust Valves.

A. After 185 hr. endurance using fuel with 4.6 ml. TEL (1.5-T fluid) per gallon.
B. After 240 hr. endurance using fuel with 4.6 ml. TEL (1-T fluid) per gallon.

hrs. This is true even of the four-row radial engines of very large size. Furthermore, the lead fouling of spark plugs can be duplicated on a single-cylinder engine. This seems to be hard to demonstrate on miniature engines, but can be done repeatedly in the full-scale cylinder. This shows that maldistribution is not necessary for plug fouling, although, of course, it aggravates fouling. At any rate, the results of the three main engine endurance tests were as follows:

Lead Deposition:

The use of 1.5-T fluid resulted in a noticeable decrease in lead deposition. Though many spark plugs failed in the second and third tests, none of them were removed because of lead fouling. In addition, the valves were substantially free from lead deposits. Figures 3 and 4 compare a relatively clean valve from the 1.5-T test with one from a similar test using 1-T fluid.

Spark Plugs:

When the Ethyl fluid was changed from 1-T to 1.5-T the rate of spark plug failures increased from 4.8 per 100 operating hours (most of which were due

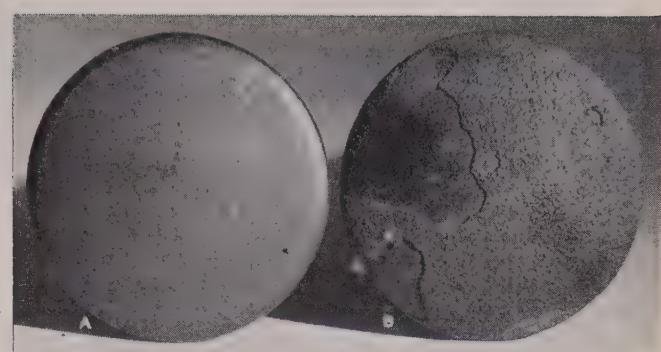


Fig. 4.—R-2800 Exhaust Valves.

A. After 185 hr. endurance using fuel with 4.6 ml. TEL (1.5-T fluid) per gallon.
B. After 240 hr. endurance using fuel with 4.6 ml. TEL (1-T fluid) per gallon.

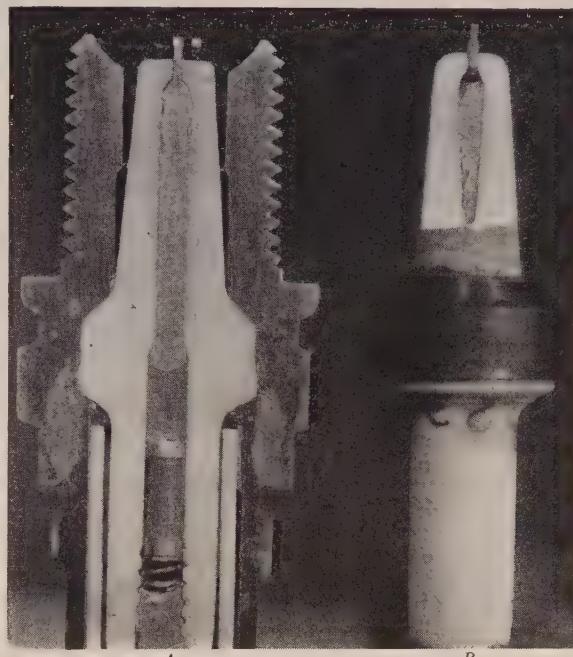


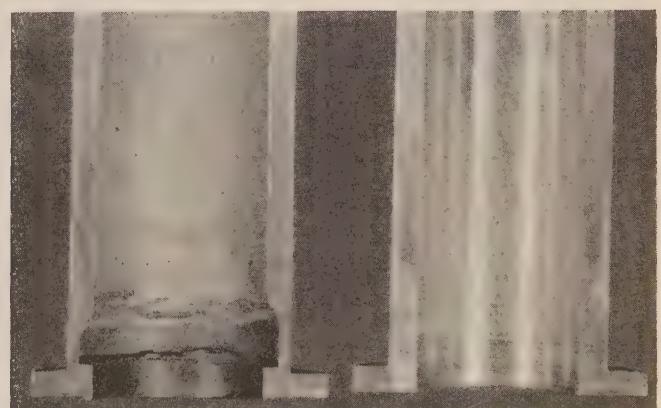
Fig. 5.—R-2800 Spark Plugs.

A. New lug section view.
B. After 132.36 hr. endurance with 4.6 ml. TEL (1.5-T fluid) per gallon.



Fig. 6.—R-2800 Spark Plugs.

A. After 211.4 hr. endurance using fuel with 4.6 ml. TEL (1.5-T fluid) per gallon. Operated in No. 4 cylinder, rear position.
B. New.



After 185 hr. endurance with 4.6 ml. TEL (1.5-T fluid) per gallon

New

Fig. 7.—R-2800 Exhaust Valve Guides.

to lead fouling) to 10.3 failures per 100 hr. Instead of lead fouling, essential parts of the plugs were removed by the corrosive action of the bromide. In about half of the failures, the silver solder which supports the center electrode was attacked, allowing the electrode to loosen and fall out. In the past, we have considered the loosening of the center electrode as a mechanical failure, but it now appears that the lead alloys with the silver used to hold the center electrode, forming a lower melting point material and thus allowing the center electrode to loosen. In Fig. 5 a cross-section of a new spark plug is compared with a section of a plug which has lost some of its silver solder in the test. Most of the other failures were due to corrosive attack on the steel bosses which support the outside electrodes. Figure 6 is typical of such a failure.

The spark plug failures were divided about 50-50 between the front and rear banks of cylinders. Similarly, plugs failed equally often in both front and rear positions in the individual cylinders. This, and the fact that the troubles can be reproduced in a single-cylinder engine indicate that the failures cannot be attributed to maldistribution of the substances involved.

Valves and Valve Guides:

Though the valves were quite free of lead deposits, they were subject to the more serious troubles of corrosion and wear. Several exhaust valve domes were corroded so that the stellite faces were exposed. The exhaust valve stems were badly eroded and worn. In 300 hr. the stems were worn as much as 0.004 in. in diameter.

The exhaust valve guides were also worn as much as 0.02 in. on the inside diameter. This, coupled with the valve stem wear, gives a greatly enlarged valve-to-guide clearance, resulting in overheating of the valve and perhaps in its malfunctioning as well. Most of the exhaust guides were also attacked at the brazed joint between the steel scraper ring and the rest of the guide. Figure 7 shows such a failure.

Valve Seats:

The tests on fuel containing 1.5-T fluid were interrupted most often by failures of exhaust valve seats. Such failures, which occurred on the average of 2.7 times per 100 operating hours, could be detected by backfiring and decreased valve clearance. All the exhaust seats were corroded or eroded in the area beneath the valve head. The material was actually worn away to a depth of $\frac{1}{2}$ to $\frac{1}{4}$ in. (see Fig. 8). This allowed the valve to sink until the

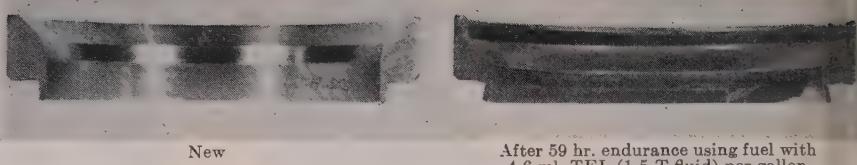


Fig. 8.—R-2800 Exhaust Valve Seats.

clearance was used up, at which point the valve would be held open and backfiring result. Figure 9 shows a section view of an exhaust ear. It can be seen that the valve seat is worn away, allowing the valve to remain open. Possibly the recessing of the exhaust valve seats could be overcome by facing the seats with stellite, but this would fix only one of the troubles, and at considerable cost.

Bearings:

The engines used in tests Nos. II and III did not start with new main bearings, since no bearing trouble was anticipated. However, careful examination of the bearings after the endurance tests gave some cause for concern, for the bearing condition had deteriorated noticeably. The bearings of the 185-hr. engine were inspected and photographed before and after the test and showed considerable loss of surface material. The master rod bearings were worst, with the cam bearings and front and rear main bearings somewhat corroded. The bronze bushings throughout the engine seemed unaffected.

The oil consumption increased regularly throughout the test, whereas it is usual for the oil consumption to decrease continually in a test of this duration. This is evidence of increased wear.

CONCLUSIONS

From these tests it is evident that the use of excess ethylene dibromide aviation fuel forms residues which are highly corrosive to the metals we presently use in all our engines. The fact that lead deposition was negligible in these tests demonstrates that lead scavenging can be accomplished and that development of a noncorrosive agent for this purpose is highly desirable.

Several important laboratories have done a good deal of work in the search for better scavengers, and we think it is not only possible but quite likely that a better one will be developed. The alternative to such an agent would be the development of an effective anti-knock compound without the propensity for deposition shown by tetraethyl lead.

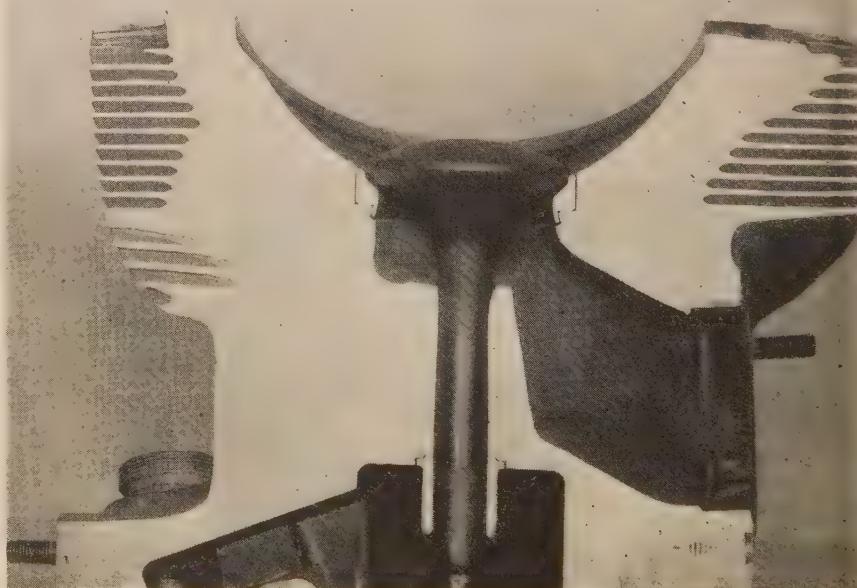


Fig. 9.—R-2800 Exhaust Ear and Valve after 179 hr. Endurance Using Fuel with 4.6 ml. TEL (1.5-T Fluid) per Gallon.

Requirements of an Engine Antifreeze and Methods of Evaluation¹

By D. H. Green,² J. C. Kratzer,² P. I. Emch²

SYNOPSIS

The growing need for industrial standards in engine antifreeze, as indicated by the greater demands on internal combustion engines in all classes of service, has been brought more sharply into focus by the use of stop-gap antifreeze materials when products of known and accepted quality were in short supply. The test methods, data, and conclusions discussed in this paper are based on 20 yr. of experience in research, development, testing, and field service of this organization and are offered for whatever value they may have in the development of suitable antifreeze standards.

The requirements of an engine antifreeze are broadly classified as (1) dependable freezing protection, (2) adequate engine cooling, (3) effective protection against corrosion, and (4) retainability in the cooling system. An integrated test program of laboratory, full-scale engine-dynamometer, and vehicle driving procedures has been adopted for antifreeze development and evaluation. Each phase of this integrated test program serves a special purpose, and none has been found satisfactory as a substitute for any other phase. The value of laboratory type tests usually diminish as service simulation is attempted. Engine dynamometer methods are a closer approximation of field service, but only vehicle driving tests can assure that a newly developed antifreeze will meet all the requirements of a satisfactory winter coolant.

THE improvements in internal combustion engines, and the great demands imposed upon them in all classes of service, have resulted in the need for higher standards of engine cooling maintenance. Increased vehicle mileage and speed during the cold weather months and the higher operating temperatures desirable for engine performance and for driver comfort have placed special emphasis on properties of nonfreezing coolants other than freezing point. The growing need for industrial standards for engine antifreeze, indicated by these developments, has been brought more sharply into focus by the use of stop-gap antifreeze materials during recent periods when products of known and accepted quality were in short supply.

This presentation of engine antifreeze requirements and methods of evaluation represents the viewpoints of large producer and national marketer of inhibited ethylene glycol and methyl alcohol antifreezes. The test methods, data, and conclusions are based on 20 years' experience in research, development, testing and field service, and are offered for whatever value they may have in the development of suitable antifreeze standards.

The final and conclusive test of an antifreeze is satisfactory service in the

ESSENTIAL SERVICE REQUIREMENTS OF AN ENGINE ANTIFREEZE

Based on field reports covering first-hand investigations of engine-cooling failures (1), the following broad classification of service requirements has been found useful in antifreeze development and evaluation studies:

1. Dependable freezing protection,
2. Adequate engine cooling,
3. Effective protection against corrosion, and
4. Retainability in the cooling system.

Dependable Freezing Protection:

The freezing-point depressing action of an antifreeze compound in water is a property which can be readily measured by laboratory test methods. Loss of freezing protection through chemical decomposition during use is negligible with common organic antifreeze materials such as ethylene glycol, methyl alcohol, and ethyl alcohol, although this factor must be considered when any experimental nonfreezing coolants are being evaluated. However, the boiling point of the antifreeze solution may have an indirect effect on the dependability of freezing protection since local boiling in the engine water jacket may cause solution overflow loss.



Fig. 1—Corroded Water Pump Impeller.

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² National Carbon Co., Inc., New York, N. Y.



Fig. 2.—Corroded Water Distribution Tube.

Adequate Engine Cooling:

No less important than dependable freezing protection is the heat transfer ability of the coolant. Water solutions of the commonly used organic anti-freeze materials are generally accepted as adequate for internal combustion engines designed for water cooling. Further departure from the standard of water cooling will warrant thorough investigation of temperature effects on engine performance and maintenance costs, since the heat transfer ability of the coolant is a basic factor in engine temperature control.

Selection of a satisfactory heat transfer medium is still no guarantee that adequate engine cooling will continue indefinitely in service, unless the adverse effect of corrosion and corrosion products on heat transfer are also controlled. This likewise applies to any deteriorating effects of the coolant on rubber hose connections, gaskets, or other nonmetallic parts that may interfere with heat transfer in the cooling system.

Effective Corrosion Protection:

The necessity for effective inhibition of the coolant to protect all cooling system metals against corrosion can be readily appreciated when the detrimental effects of corrosion on cooling-system operation and maintenance are considered. Metals encountered in the cooling system include cast iron, steel, brass, copper, solder and, at times, aluminum. Factors which accelerate corrosion in the cooling system include coolant flow characteristics, aeration, combustion gas leakage into the coolant, corrosion products, couples of dissimilar metals, stresses in metal, localized metal hot spots, coolant operating temperatures, and coolant water supplies containing salts such as chlorides and sul-

fates. The cooling system corrosion problem is further complicated by miscellaneous contaminants introduced through the use of unsuitable additives, or the misuse of suitable additives intended for corrosion inhibition, leakage prevention, or cleaning.

Corrosion Damage.—Engine-cooling failures from corrosion of metal parts in the cooling system, while less frequent than failures due to clogging of the system by the products of corrosion, have equally serious effects. Corrosive attack of a cast-iron water pump impeller which results in reduced coolant circulation and cooling efficiency is shown in Fig. 1.

In the engine water jacket, corrosion of the coolant-distribution tube may result in insufficient cooling of such critical areas as the exhaust valve seats. The section of the distribution tube



Fig. 3.—Failed Thermostat.

shown in Fig. 2 is so badly corroded as to be hardly recognizable.

In the bellows type thermostat, solo corrosion may result in failure of the actuating unit, which regulates the flow of coolant to the radiator, causing loss of engine temperature control. Figure 3 shows the thermostat valve inoperable in the open position.

Another example of non-ferrous metal corrosion damage is illustrated in Fig. 4, where perforation has occurred in the thin wall of the radiator water passage and has resulted in leakage loss of coolant.

Corrosion as a cause of leakage is again illustrated in Fig. 5, showing perforation of a water jacket core-hole closure made of cold formed steel. The perforation—hardly visible, but nonetheless the less serious as a cause of coolant loss.

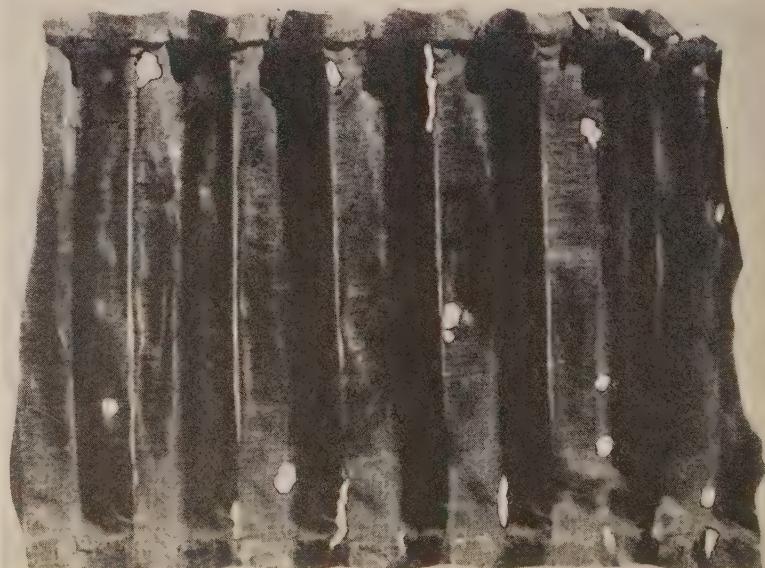


Fig. 4.—Corroded Radiator Water-Tube Wall.



Fig. 5.—Corroded Core Hole Plug.

s located in the upper part of the k.

internal leakage of the water jacket used by corrosion at the cylinder head joint is an additional hazard since leakage of coolant into the engine may result in lubrication failure and even serious engine damage.

Rust Clogging.—The presence of large quantities of iron rust in the cooling system is explained by the fact that iron is more susceptible to corrosion than other commonly used metals. Also, a comparatively large surface area of iron is in contact with coolant in the water jacket. Figure 6 is a view into the water jacket with the cover plate removed, showing the magnitude and character of cast formations that are possible with uninhibited or contaminated coolant. The problem of rust formation as a factor in restriction of coolant flow and reduction of cooling efficiency is usually more acute in the radiator than in the water jacket because of the ease with which the small water passages can be clogged. Rust particles carried over to the radiator from the water jacket by coolant circulation first deposit in the form of a thin film which interferes with heat transfer and finally plugs the water tubes, blocking off practically all coolant circulation through the radiator core. Figure 7, looking down into the water tubes, illustrates such an extreme clogging condition.

Effect of Corrosion Products on Antifreeze Inhibitors.—Corrosion products, especially those of cast iron, tend to reduce the effectiveness and service life of antifreeze corrosion inhibitors (Table II). The effect of rust on inhibitors varies with its physical and chemical composition. Ordinary laboratory grade ferric or magnetic oxides of iron have practically no effect, whereas, the occultant, hydrated iron oxides, formed by normal rusting of the cast-iron



Fig. 6.—Badly Rusted Engine Water Jacket.

water-jacket by uninhibited coolants, have a very detrimental effect on corrosion inhibition. This effect of rust accounts in part for the variations in inhibitor effectiveness and service life sometimes found with the same type of coolant in different test vehicles.

Copper corrosion products in solution can have a marked catalytic effect on the oxidation of organic antifreeze, with resultant depletion of inhibitors and reduced corrosion protection and inhibitor life. Another undesirable effect of cuprous metal corrosion is the plating out of dissolved copper on other metals, a process which stimulates electrolytic corrosion.

Corrosion Inhibitors.—The need for more general use of effectively inhibited coolant is strongly indicated by the prevalence of cooling system corrosion and rust clogging.

Substantial progress has been made in the chemical control of cooling-system corrosion by the development of specific inhibitor formulas. Standard antifreeze products have contained corrosion-preventive ingredients for a number of years, and commercial inhibitor preparations are generally available for use with water when antifreeze is not required.

The benefits derived from the use of inhibited antifreezes are reduced by the

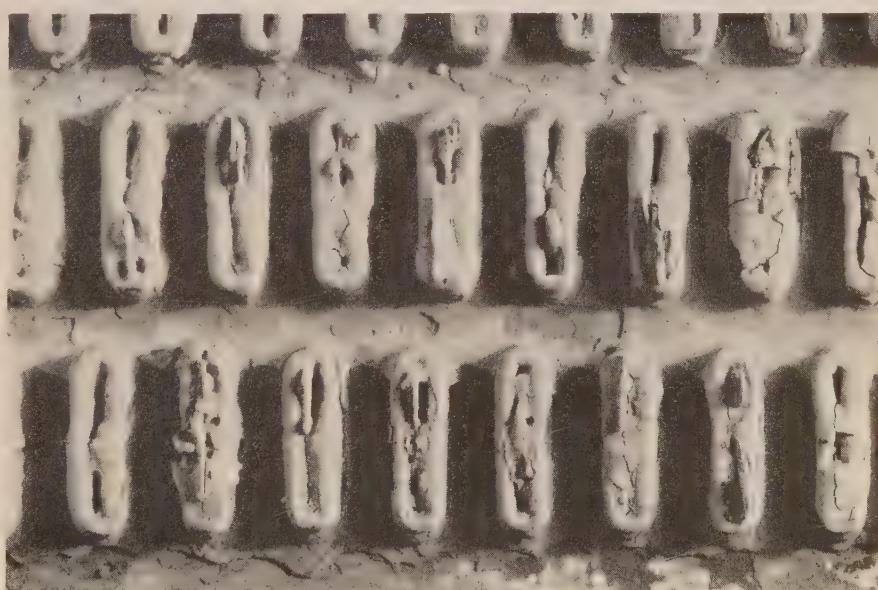


Fig. 7.—Rust Clogged Radiator Tubes.

continued use of the solution beyond the end of effective inhibitor life, and the indiscriminate addition of reinhibiting compounds regardless of the condition of the used antifreeze solutions. Life expectancy of antifreeze inhibitors is shortened by such major service variables as (1) driving mileage, (2) engine speed and loading, (3) aeration of coolant, (4) combustion gas leakage into coolant, (5) localized hot spots in engine, (6) rust deposits in system, and (7) contamination due to cleaners, stop-leaks, etc. Since these service variables affecting inhibitor life are often beyond the consumer's knowledge and control, a practical approach to corrosion control is the arbitrary practice of (1) installing a fresh, inhibited antifreeze each fall, (2) discarding the solution in the spring regardless of its condition, (3) cleaning the system if necessary, and (4) adding rust inhibitor to a fresh filling of water for warm weather driving.

In any departure from this practice the consumer without laboratory facilities, has only the change in solution appearance with respect to rust as a guide to renewing antifreeze, and this requires more frequent inspections of coolant condition. The weaknesses of this rough guide are, on one hand, the possibility of premature renewal of solution which is satisfactory from the standpoint of corrosion protection but has been contaminated with rust already present in the system at the time of antifreeze installation and, on the other hand, the failure to observe the solution condition change or to replace the solution when necessary.

Retainability in the Cooling System:

Practically all antifreeze solution losses occur in one of two ways: (a) as a result of cooling system leakage, or (b) from coolant overflow. With inhibited antifreezes, solution loss results not only in loss of the antifreeze material but also in depletion of the inhibitor ingredients with a consequent reduction in corrosion inhibitor effectiveness and service life.

Leakage Loss.—Coolant shortage as a result of leakage accounts for more engine-cooling failures than any other cause. The most common points of cooling system leakage are (1) water pump, (2) radiator, (3) hose connections (4) cylinder head and other gasketed joints. Pressure, due to pumping action and the use of pressure caps, increases leakage tendencies. While leakage is primarily a function of cooling system soundness rather than of antifreeze solution characteristics, it can be aggravated by deterioration of nonmetal parts such as hoses, gaskets, and pump seals as well as by corrosion of metal parts.

There is a popular misconception that glycol antifreezes generally leak more

than water. Tests in radiators have shown that the rates of leakage of uninhibited glycol solutions through small crevices may be somewhat greater than that of water. This is probably due to osmotic effects or to the loosening action of uninhibited glycol on rust which plugged existing leaks during the use of water. This type of slow leakage, referred to as seepage, accounts for only a small part of the total coolant leakage losses, but in the case of glycols it appears to be of considerable psychological importance. Glycol solution leakage evaporates less rapidly than water or alcohol solutions from outside surfaces, which gives a misleading impression of the relative leakage. In the case of larger leaks, where losses with water are appreciable the glycol solution leakage rate may be less than that of water, due to viscosity effects (see Table VIII).

The beneficial effect on seepage losses of an antiseep agent incorporated in the antifreeze can be demonstrated in the laboratory, but this appears to be overshadowed by losses from larger leaks in vehicle driving tests. The effect of an oil type antiseep in retarding the natural rust-loosening action of glycol is clearly indicated in vehicle driving tests by the higher percentage of rust-free solutions in old, high-mileage vehicles.

Leakage occurring at approximately the dripping rate can be substantially reduced by specific antileak ingredients compounded with the antifreeze as an integral part of the formula (Table X), but permanent correction of any type of leak can be assured only by repair or replacement of the defective parts.

Overflow Loss.—Coolant may be lost through the overflow pipe by overfilling, thermal expansion, partial restriction of coolant flow through the radiator, coolant surging, combustion gas leakage, aeration, after-boil, and acute overheating from any causes such as obstructed or inadequate coolant or air circulation. The three principal properties of the coolant directly related to overflow loss are boiling point, foaming tendency, and thermal expansion. Contrary to the popular conception, evaporation has been found to be a negligible service factor in solution loss even with low boiling point alcohol antifreezes (2).³

(a) **Boiling Point.**—Since the boiling point of water is lowered by additions of ethanol and methanol and raised by additions of ethylene glycol in proportion to the amount required for freezing protection, it is apparent that the normal operating temperature of the engine may be an important consideration in the selection of the most suitable type of antifreeze. (3, 4) Using 212 F. boiling

point as a reference base for the conventional water-cooled engine, the loss of the boiling-point safety factor with alcohol solutions is indicated by the fact that a solution concentration necessary to protect to -20 F. will boil at approximately 180 F. On the other hand, the boiling point of an ethylene glycol solution protecting to -20 F. is 223 F., thus providing a boiling-point factor safety larger than that of water. Boiling points of water and antifreeze solutions of course are affected by altitude and by pressure in closed cooling systems, but any difference in boiling-point effect among the commonly used coolants is negligible.

Overflow loss of coolant from boiling can take place during engine operation or vehicle driving but is most likely to occur when the engine is slowed down or stopped after a hard run. With the engine stopped or running at idle speed with the rate of coolant circulation greatly reduced, the residual heat in the engine block causes a sharp temperature rise in the stagnant coolant. When the temperature of the coolant rises to its boiling point, the vapors displace liquid in the jacket, forcing coolant into the radiator and out the overflow pipe. Overflow loss from boiling under these particular conditions has been called "after-boil." Since the margin of boiling-point safety is a critical factor in "after-boil" loss, it is readily apparent that ethylene glycol antifreeze would reduce the loss as compared to water and that alcohol solutions would substantially increase it. A comparison of ethylene glycol and alcohol solution losses by "after-boil" in a closely checked field test conducted during the winter months at Buffalo, N. Y. is given in Table XII.

(b) **Foaming Tendency.**—For the purposes of this discussion, foaming tendency is defined as the ability of a liquid to entrain and hold gas or vapor in the body of the liquid, thus increasing its over-all volume, and does not necessarily refer to the tendency toward formation of bubbles on the surface of the liquid. The foaming tendency of an antifreeze solution is an important consideration in the retainability of the solution in the cooling system. Aeration in the cooling system is normally brought about by (1) coolant turbulence in the top tank at high coolant velocities which traps air, and (2) coolant circulation which carries the air bubbles throughout the system. Abnormal top tank turbulence due to low coolant level, air suction in the system, and combustion gas leakage into the coolant, are the principal service factors that cause excessive aeration and magnify the foaming problem.

³ The boldface numbers in parentheses refer to list of references appended to the paper.

Engine dynamometer (5) and vehicle service studies have shown that antifreeze concentration, coolant temperature, service age, water hardness, and solution contamination all affect coolant foaming tendencies; it has also been demonstrated that suitable "defoamers" in an antifreeze reduce foaming losses to negligible proportions for long service ages and under severe operating conditions (Table XI).

(c) *Thermal Expansion.*—Although the thermal expansion of common organic antifreeze solutions is slightly greater than that of water, the difference creates no special overflow loss problem if the proper coolant level in the radiator is maintained. The conventional cooling system design provides sufficient reserve capacity to accommodate the thermal increase in antifreeze solution volume due to thermal expansion; the common problem of overflow loss from this cause is due to the widespread practice of overfilling the radiator. The relative quantities of water and of antifreeze solutions which may be lost through overflow from thermal expansion when the radiator is overfilled are indicated by the following data on volume increase in pints per gallon, through the comparable temperature range of 40 F. to 180 F.: water 0.24; ethylene glycol, methanol, and ethanol solutions (protecting to -20 F.): 0.37, 0.44, and 0.54, respectively (6).

METHODS OF EVALUATING ANTIFREEZE

While the technical value of a test program must receive first consideration, the cost of setting up and maintaining equipment, the number and quality of personnel employed, and the time required for completion are, of course, also important factors. It is appreciated that the integrated program of test procedures followed by this organization for antifreeze development and evaluation may not be feasible except for comparatively large producers. However, experience has shown that anything short of this program may result in a new antifreeze compound with definite weaknesses (as measured by service standards) reaching the production stage. In the following discussion no attempt is made to give complete details of the test methods used, but essential test components and conditions are reviewed for the purpose of evaluating their usefulness and limitations.

Laboratory Screening Tests:

A wide variety of laboratory type tests have been used as preliminary screening tools for antifreeze development and evaluation work. These have ranged from simple static beaker tests to circulating type units utilizing full-

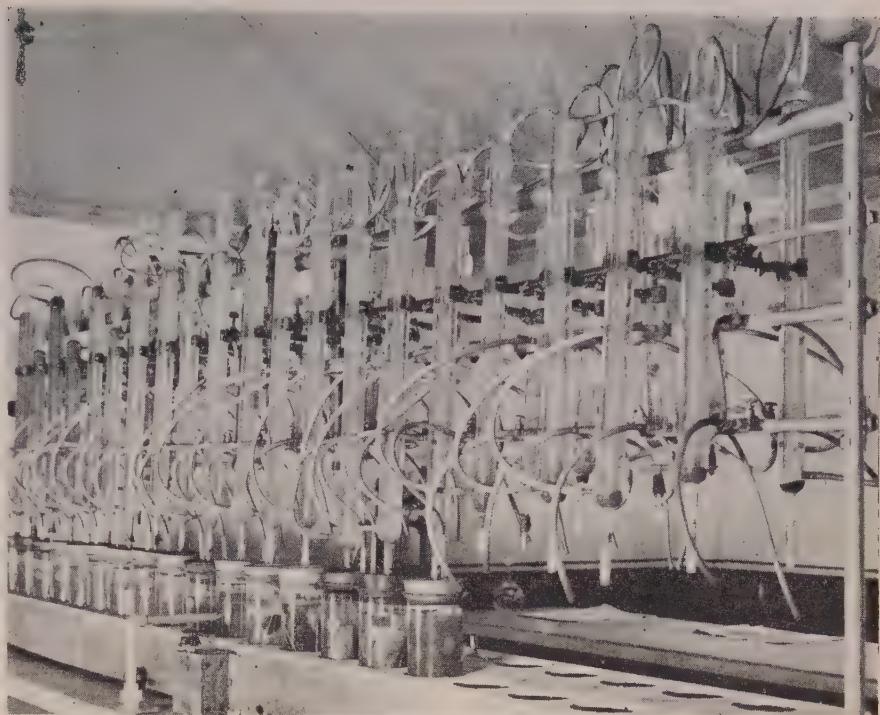


Fig. 8.—Laboratory Corrosion Test Units.

scale cooling system parts. The primary requisites of laboratory methods are comparatively short duration, reproducibility of results, adaptation to multiple unit construction, low cost, and ease of operation with nontechnical personnel. It has been the experience of the authors that as laboratory tests are made more complex, in the attempt to simulate service conditions, the desired features are often sacrificed. No dependable measure of service life has as yet been found in laboratory tests.

TABLE I.—TYPICAL 200-HR. CORROSION TEST RESULTS.
Composition brass specimen—67 per cent copper, 33 per cent zinc.
Composition solder specimen—50 per cent lead, 50 per cent tin.

Solution	Corrosion Losses, mg. per 9 sq. in.				
	Iron ^a	Alumi-nium	Brass	Copper	Solder
Distilled water.....	1140P+	4	70	70	175
Inhibited water.....	1	2	10	15	20
Uninhibited 33 per cent ethylene glycol.....	300P+	20	85	100	24
Inhibited 33 per cent ethylene glycol.....	0	2	4	6	3
Uninhibited 27 per cent methanol.....	375	4	31	26	15
Inhibited 27 per cent methanol.....	1	4	4	5	6

^a P+ = Slight pitting.

TABLE II.—CORROSION LOSS COMPARISON OF ONE COMMERCIAL INHIBITED CHLORIDE SOLUTION WITH INHIBITED ETHYLENE GLYCOL IN 200-HR. TEST UNIT.

Solution	Corrosion Losses, mg. per 9 sq. in. ^a				
	Iron	Alumi-nium	Brass	Copper	Solder
33 per cent inhibited chloride solution.....	+19	41	25	33	+2
33 per cent inhibited ethylene glycol solution.....	0	2	4	6	3

^a + signs indicate increase in weight of specimen.

TABLE III.—EFFECT OF RUST ON CORROSION RATE IN 200-HR. CORROSION TEST.
(Corrosion losses averaged from four different antifreeze formulas)

Amount of Rust ^a	Corrosion Losses, mg. per 4½ sq. in.				Solder spots ^b
	Iron	Aluminum	Brass	Copper	
None.....	9	2	11	11	6
Moderate.....	32	15	7	21	6
Large.....	1290	70	8	65	5

^a On six 1/8-in. thick, 2-in. diameter cast-iron disks which have been pre-rusted and immersed in the test solution.

^b Ratings: 6 = excellent; 1 = very poor.

during the operating period. Typical corrosion test specimens are shown in Figs. 9 and 10. Aluminum may be darkened, pitted to different degrees, or copper plated. Solder spots on brass or copper show different degrees of attack and are rated visually according to the standards. Copper, solder, and brass show darkening or tarnishing; brass may also show dezincification. Iron shows etching, pitting, and copper plating. A new or experimental antifreeze is mixed with distilled water to give a freezing protection of 0 F. and run for 200 hr. The conditions of this test were selected to give large corrosion losses for uninhibited water and for uninhibited antifreeze. The duration of test has been limited to 200 hr. for the definite purpose of evaluating inhibitor effectiveness and not service life.

The benefits of inhibitors are readily detected in this test, as illustrated in Table I, which shows corrosion values obtained on both uninhibited and inhibited water and antifreeze materials. Low corrosion losses on this test do not necessarily mean that the antifreeze will be suitable in service but merely indicate that the favorable results warrant further study. The weaknesses of this test for simulating service conditions are clearly illustrated through a comparison of the data in Table II and the photographs in Fig. 11.

As indicated in Table II, the corrosion losses of a commercial chromate-inhibited calcium chloride solution and of an effectively inhibited ethylene glycol solution were both within satisfactory limits for this screening test. However, the badly rusted water pump impeller from a road test vehicle, shown in Fig. 11, developed in only 2000 miles of service with this chloride antifreeze, while the water pump impeller shown on the right was still in good condition after approximately 20,000 miles with the ethylene glycol antifreeze.

As indicated previously, field service variables can affect the inhibitor effectiveness and useful life of an antifreeze, and it is desirable to make a tentative evaluation of the sensitivity of an antifreeze formula to these variables in the laboratory. Consequently, a number of modifications of the basic static type of test are used. One such variation utilizes pre-rusted cast-iron specimens in the beaker to determine the effect of rust on inhibitor action. Table III shows the increased corrosion rate produced by the presence of rusted iron specimens. The addition of ferric oxide to the test solution, as a substitute for pre-rusting of specimens in this test, has essentially no effect on increasing the test severity.

Another helpful test variation has been the use of synthetically prepared

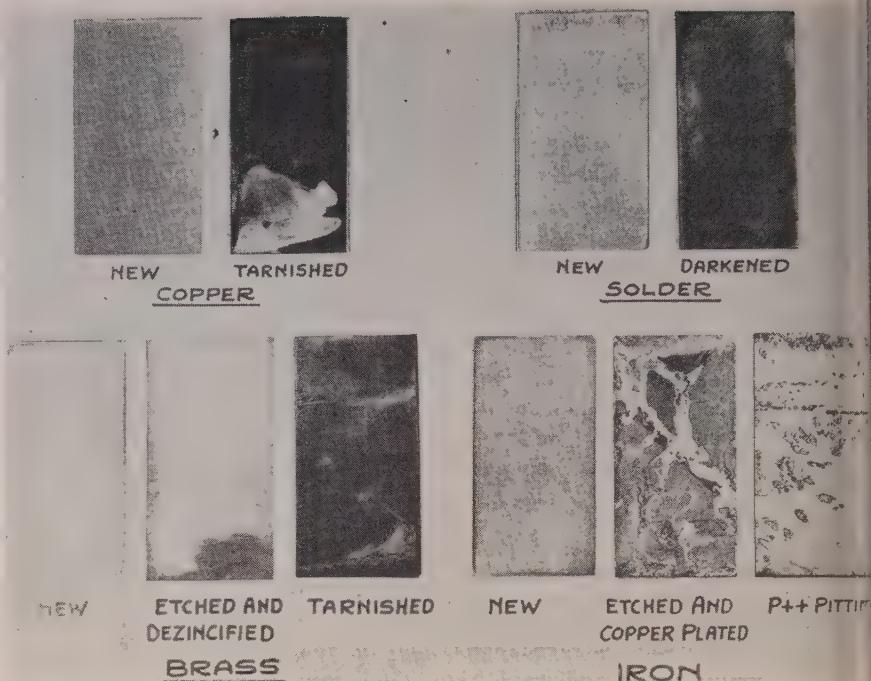


Fig. 9.—Typical Corrosion Pattern of Laboratory Test Specimens.

TABLE IV.—SENSITIVITY OF ANTIFREEZE SOLUTIONS TO CORROSION WATER AS DETERMINED BY THE 200-HR. CORROSION TEST.

Test Solution	Corrosion Losses, mg. per 9 sq. in.				
	Iron	Aluminum	Brass	Copper	Solder
Antifreeze A with distilled water.....	9	8	59	37	17
Antifreeze A with corrosive water ^a	205	38	59	30	44
Antifreeze B with distilled water.....	1	1	4	9	11
Antifreeze B with corrosive water ^a	3	16	5	12	18

^a 200 ppm. sodium sulfate and 300 ppm. of sodium chloride added to distilled water.

TABLE V.—EFFECT OF COUPLING THE CORROSION SPECIMENS IN THE 200-HR. CORROSION TEST.

(Corrosion losses averaged from four different antifreeze formulas)

Test Variable	Corrosion Losses, mg. per 9 sq. in.				
	Iron	Aluminum	Brass	Copper	Solder Spots
Coupled specimens.....	5	16	12	9	6
Uncoupled specimens.....	17	4	21	20	6

^a Rating: 6 = excellent; 1 = very poor.

TABLE VI.—EFFECT OF TEMPERATURE ON THE CORROSIVENESS OF TONAWANDA TAP WATER (SOURCE: LAKE ERIE) IN THE 200-HR. CORROSION TEST.

Test Temperature, deg. Fahr.	Corrosion Losses, mg. per 9 sq. in.				
	Iron	Aluminum	Brass	Copper	Solder
70.....	590	13	9	5	9
120.....	780	19	41	19	14
170.....	1230	28	33	18	29
190.....	1160	79	11	43	2

TABLE VII.—EFFECT OF SOLUTION AERATION ON CORROSION IN THE 200-HR. CORROSION TEST.

Test Conditions	Corrosion Losses, mg. per 9 sq. in.				
	Iron ^a	Aluminum	Brass	Copper	Solder
1. Distilled water Not aerated.....	41	0	2	1	4
Aerated (0.028 cu. ft. per min.).....	1140P+	4	70	70	175
2. Royal Oak, Michigan Tap Water (Source: deep wells) Not aerated.....	4	0	8	7	10
Aerated (0.028 cu. ft. per min.).....	640	155	25	85	120

^a P+ = Slight pitting.

ALUMINUM SPECIMENS

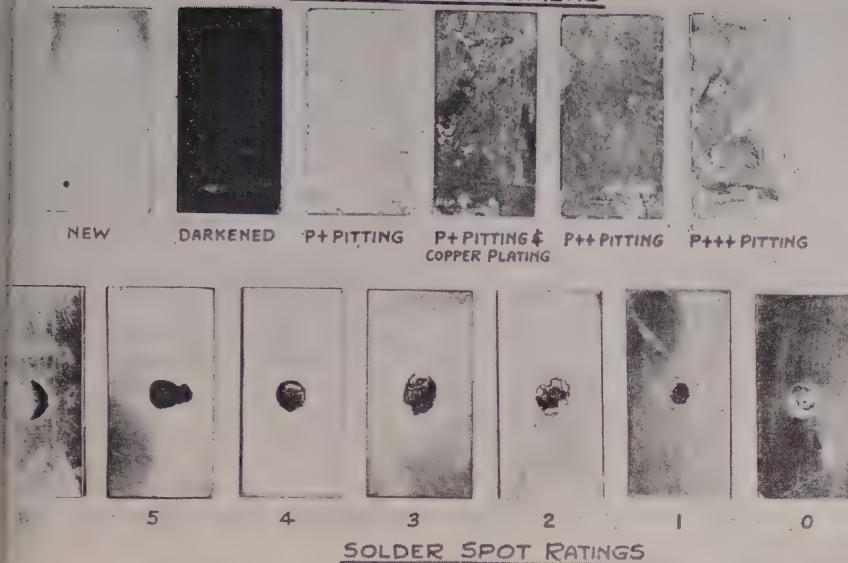


Fig. 10.—Typical Corrosion Pattern of Aluminum and Solder Spot Specimens.

rrosive water (200 ppm. sodium sulfite and 300 ppm. of sodium chloride) the solution under test. The value of the test as an indicator of the sensitivity of an antifreeze formula to such contamination is illustrated in Table IV.

It will be seen from Table IV that the superiority of antifreeze B over antifreeze A is more pronounced in corrosive water than in distilled water, particularly with respect to iron losses.

Other modifications in the test to magnify specific service variables consist of coupling the metal specimens, varying the solution temperature, and varying the rate of solution aeration. Table V shows that in this particular laboratory test, coupling the corrosion specimens has very little effect on the corrosion results with inhibited organic antifreeze solutions. However, under some conditions of test, coupling the specimens increases the severity of corrosion appreciably. This variable should not be overlooked in a testing program.

As would be expected, increasing the temperature of the test solution generally increases the severity of corrosion as shown in Table VI. The selection of 170 F. as the temperature of the test solution seems reasonable in view of present-day automotive cooling system operating temperatures. This temperature also approaches the boiling-point limit for commonly used ethanol and methanol solutions.

Dispersion of air in the test solution increases the corrosion of the metal specimens significantly, as illustrated in Table VII. The presence of air in the cooling liquid of a vehicle is such a common service factor that the inclusion of

aeration, as one of the basic conditions of this laboratory test, is considered warranted. In addition to the functions illustrated, this laboratory test is used periodically to study samples of antifreeze taken from engine dynamometer and vehicle driving tests and thus spot check solution deterioration and inhibitor depletion during use in the cooling system.

Special laboratory test units have been used to evaluate foaming, after-boil, rubber swelling, and leakage characteristics. One example of data from a laboratory leakage test unit utilizing a circulating system incorporating a standard automobile radiator is

shown in Table VIII. These data show

TABLE VIII.—RADIATOR LEAKAGE RATES.

Radiator	Leakage Rate, ml. per hr. with	
	Water	35 per cent Ethylene Glycol (uninhibited)
A. Leaking very slightly.....	4	4.1
B. Leaking badly.....	827	511

the relative rates of leakage of water and of a solution of uninhibited ethylene glycol through two crevices of different sizes. Such special tests are generally designed to magnify and study individual variables and have not been found suitable to predict field performance.

Full-Scale Engine Dynamometer Test:

Engine dynamometer tests provide a very valuable intermediate step between chemical laboratory procedures and vehicle driving tests. By means of these tests, antifreeze can be evaluated in full-scale equipment under known and controlled conditions. The engine dynamometer serves as a final screening tool prior to driving tests.

The basic engine test consists of continuous operation at 60 mph., 30-hp. load, and 180 F. coolant temperature (for ethylene glycol) in standard makes of light passenger car engines. Under these conditions the effects of operation on antifreeze inhibitor effectiveness and life are followed by periodic checks of (1) solution pH, (2) titratable alkalinity or acidity when applicable, (3) concentration of corrosion inhibitor, (4) dissolved and suspended solids, (5) appearance, (6) weight loss of corrosion

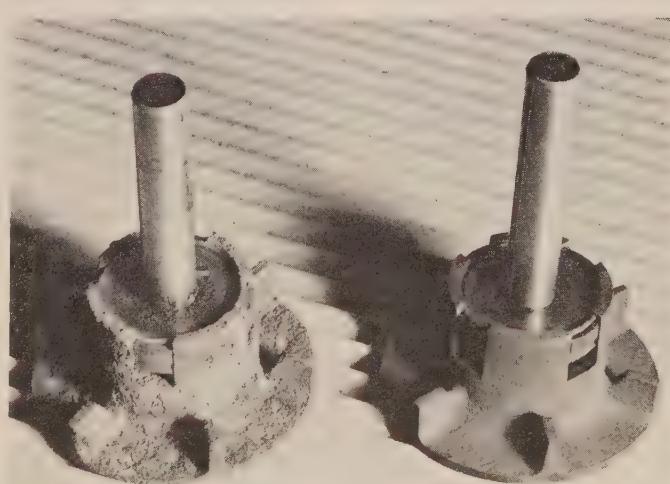


Fig. 11.—Comparison of Water Pump Impeller Condition:

Left Impeller—Operated 2000 miles with a commercial chromate-inhibited calcium chloride solution.

Right Impeller—Operated 20,000 miles with inhibited ethylene glycol solution.

specimens, and (7) examination of cooling system parts at the conclusion of the test. Specific variables can readily be studied by modification of this basic test procedure, such as engine operation (1) under cyclic conditions, (2) with varying solution concentration and temperature, (3) under specific malfunction conditions such as combustion gas leakage into the coolant, aeration through leakage points or low coolant level, and (4) with specific contaminants in the coolant such as residual cleaning compound, excessive rust, high chloride waters, etc., in combination with any of the other specific service variables.

Usually the foaming tendency and the inhibitor life of a formula can be evaluated on the same dynamometer run. The test conditions chosen to evaluate foaming were arrived at after considerable study of the foaming problem in actual service. There appear to be three operating conditions that induce foaming losses. One occurs during sustained, constant, and usually high-speed driving; another occurs during the deceleration period after high-speed operation or from a series of accelerations and decelerations; and a third occurs as a result of air or vapor introduced into the coolant. These three conditions are simulated after each 2000 miles of engine operation on the formula, and in this way the effect of aging on the tendency to foam is evaluated at successive mileage intervals throughout the service life of the antifreeze.

In moving from the laboratory type of test to full-scale engine evaluation there is considerable loss in test reproducibility because of the greater number of uncontrolled variables in engine operation as compared to laboratory manipulation. Engine tests require more skilled talent for their operation, as well as a larger initial investment, higher operational and maintenance costs, and a longer test period. It is not practical to attempt to simulate in engine tests all of the variables of vehicle operation, and it has been found that inhibitor mileage life values must be scaled down by a third to one-half when interpreting dynamometer results in terms of field service.

The importance of thorough screening in this intermediate step between the laboratory and the field can be appreciated best when it is realized that driving tests employing a large number of vehicles may require from 6 to 18 months for completion, depending on test objective and type of driving service.

Vehicle Driving Procedures:

A field test is the final check of an

antifreeze formula before production is approved, and its purpose is to determine the over-all suitability of the product under representative service conditions. Such a test should be subject (as far as possible) to all the variables of vehicle operation, maintenance, age, mileage, and normal driver habits of use, abuse, and neglect. To obtain data of statistical significance, it is necessary to run field tests with a comparatively large group of vehicles. Termination of tests for reasons other than those inherent in the solution itself, such as mechanical failure of the cooling system, accident, vehicle trade-in, etc., makes it desirable to start off with a test fleet of approximately 100 units and to rerun tests in case of subnormal or abnormal performance.

The principal limitation of a field test is that control and progress cannot be supervised or followed as closely as in either engine-dynamometer or laboratory tests, and considerable reliance must be placed on the driver and mechanic for information on operation and maintenance.

The normal driving practice for the particular type of vehicle service is left unchanged, and test operators are instructed to follow their past practices with respect to cooling-system cleaning, repairs and parts replacements, but to report all such information regularly. Antifreeze concentrations are installed by the test vehicle operators to insure protection to about 10 F. below the lowest anticipated winter temperature, even with tests started during warm weather and continued beyond the antifreeze season.

The only modification of the conventional cooling system ordinarily made is the installation of a calibrated glass "catch pot" connected with the radiator overflow so as to collect and hold any solution lost through the overflow pipe. Coolant level is initially established at $\frac{1}{2}$ in. below the radiator overflow point, and on coolant additions are made to the cooling system until the solution level has dropped to $\frac{1}{2}$ in. above the top of the radiator tubes. At this time overflow losses in the catch pot are returned to the cooling system, and any necessary water or antifreeze is added to restore the original coolant level and to maintain adequate freezing protection. Coolant level inspections are always made

with the engine at normal driving temperature.

At the start of the test, an installation report is made on a standard form covering car history, any necessary cooling system cleaning or repair, amount of water and antifreeze installed, vehicle mileage, and other pertinent information. Progress reports also on a standard form, are rendered monthly covering mileage, special conditions of operation and maintenance, all coolant additions to the system, solution appearance, effect on vehicle finish and general comments of the operator.

A 1-pt. coolant "installation" sample is taken after 100 miles of operation; 2-oz. samples are taken at monthly intervals; and a 1-pt. "final" sample is taken at test termination. These samples are inspected by the control laboratory for appearance, antifreeze concentration, pH, inhibitor content and contaminants. Laboratory static corrosion tests are run on the 1-pt. initial and final samples.

Except in case of accident, or trade-in, tests are terminated only on instructions from the control laboratory and engineering department. Any mechanical irregularity in the cooling system or engine is investigated by a field service engineer, and also by a laboratory technician if the need is indicated. Normal causes of test termination are inhibitor depletion and excessive dilution. The most useful type of information gained from field tests is the percentage of tests terminated at different mileage because of inhibitor depletion. An example of this type of data is given in Table IX for four different antifreeze formulas.

The magnitude of leakage losses

TABLE IX.—PERCENTAGE OF FIELD TESTS TERMINATED BECAUSE OF INHIBITOR DEPLETION IN VEHICLE DRIVING TESTS

	Antifreeze Formulas			
	A	B	C	D
Number of cars.	168	217	47	7
Average mileage	7300	7900	15 800	16 000
2500 miles	4	2	0	
5000 miles	10	6	0	
7500 miles	26	12	5	
10000 miles	50	23	6	
12500 miles	75	42	7	
15000 miles	a	a	7	
17500 miles			12	
20000 miles			17	

a Test terminated.

TABLE X.—EFFECT OF ANTILEAK ON LEAKAGE LOSSES IN VEHICLE DRIVING TESTS

Antifreeze Formula	Number of Vehicles	Average Mileage	Leakage Losses, pt. per 1000 miles
A without antileak	59 pass. cars	8100	0.51
A with antileak	19 pass. cars	17000	0.22
B without antileak	11 pass. cars	10000	1.68
B with antileak	11 pass. cars	10000	0.42
C without antileak	8 trucks	14000	2.21
C with antileak	8 trucks	31000	0.46

as the effect of antileak materials be statistically evaluated in a field as illustrated in Table X. In making this compilation, large losses from mechanical failure, such as broken hose connection, are excluded. It is apparent that close cooperation on part of the vehicle operator in conducting the test and reporting results is necessary to make such data dependable.

With the glass catch pot located in the driver's compartment, conditions under which overflow occurs and also the magnitude of the overflow can be easily observed. Typical overflow losses gathered on three glycol antifreeze formulas in a limited field test are shown in Table XI. Here again large overflow

TABLE XI.—OVERFLOW LOSSES IN VEHICLE DRIVING TESTS.

Formula	Number of Cars on Test	Average Test Mileage	Overflow Losses, pt. per 1000 miles
A....	14	10 000	1.3
B....	15	11 000	0.44
C....	13	11 500	0.04

losses caused by mechanical failures such as fan-belt breakage are not included. Formula A is considered unsatisfactory with respect to foaming,

formula B borderline, and formula C satisfactory.

The basic vehicle driving test procedure can of course be modified for study of a particular performance property of an antifreeze such as after-boil. The data in Table XII clearly indicate that the boiling-point safety factor between ethylene glycol and alcohol solutions, previously referred to, is of practical significance in winter driving.

TABLE XII.—AFTER-BOIL LOSSES. 59 CARS IN WINTER DRIVING WITH ANTI-FREEZE SOLUTION PROTECTION TO -20 F.

Type Antifreeze	Losses, pt. per 1000 miles per car
Ethylene glycol.....	0.11
Alcohol.....	1.5

CONCLUSION

Each phase of this integrated test program serves a special purpose, and none has been found satisfactory as a substitute for any other phase. The value of laboratory type tests diminishes as service simulation is attempted. Engine-dynamometer methods are a closer approximation of field service, but only vehicle driving tests can assure that a new antifreeze development will meet all the requirements of a satisfactory winter coolant.

DISCUSSION

MR. GUS KAUFMAN¹ (*presented in written form*).—The paper by Mr. Green and his co-workers based on some twenty years of intensive experience in the field of engine antifreezes certainly represents a worth-while contribution to the technical literature on this subject. As pioneers in this field they have emperered their theoretical considerations with good, practical judgment. They have recognized that it is not sufficient to develop laboratory formulas which appear to work satisfactorily by laboratory tests. They have gone forward through simulated service tests and full-scale engine-dynamometer tests to extensive field tests with a full realization of the value and significance of each—and they have given freely of their knowledge, both in this paper and preceding ones. The paper clarifies some popular misconceptions; for example, that evaporation is a significant factor in solution loss.

Also the authors bring out a point which is of extreme importance and which is generally not recognized, that is, that water itself is many times more corrosive than properly inhibited antifreeze solutions. With regard to rust

formation, it should be brought out that much of this may be scale from the hard water used in many parts of the country. The authors may wish to amplify this phase, particularly Figs. 6 and 7.

Another point which should be made is the accelerated advancement of research on antifreeze, which necessitates new understandings on what properties may identify a good antifreeze formula. It has been previously assumed, for example, that the pH should be of the order of 7 to 9. Actually superior anti-corrosion properties against steel, aluminum, brass, solder, etc., have been obtained with formulas containing special combinations of inhibitors whose pH may be well over 11. Therefore, the mere stipulation of limits for this and other laboratory tests may be all right for identification or manufacturing control, but the real criterion lies in actual field results.

If users of antifreeze would bear in mind only a small portion of the information covered by the authors and would follow the correct instructions in the use of antifreeze, they would get the full benefit of the excellent properties afforded by properly compounded antifreeze.

Acknowledgment:

Acknowledgment is made to Mr. R. A. Willihnganz for his very substantial contribution to the data contained in this paper, in his former position on the staff of the antifreeze research organization of National Carbon Co., Inc.

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MR. D. H. GREEN (*author's closure*).—Mr. Kaufman has raised a question regarding water scale as a factor in water jacket and radiator clogging particularly with hard water used in many parts of the country. Our spot analyses of cooling system deposits have shown them to consist mainly of iron rust, water scale, and grease with rust usually comprising over 90 per cent of the total deposits.

We have found the formation of lime and other water scale a minor factor in the cooling system clogging problem when overfilling and excessive water additions to replace coolant leakage and overflow losses are avoided, since the quantity of mineral salts that would produce scale is very small as compared to the volume of iron rust normally formed in uninhibited coolant. However, with high driving mileages and large water additions, water scale may be troublesome in hard water areas where calcium or magnesium or both exceed 500 ppm.

To minimize water-scale formation, the use of excessively hard water should be avoided if possible, and water additions should be kept down to an absolute minimum through preventive maintenance.

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Another question has been brought to the author's attention concerning the effect of coolant-leakage into the engine. This subject was considered outside the scope of our presentation, since with either water or the commonly used antifreezes there is only one known solution of the problem—a standard of maintenance that will keep the water jacket leaktight.

Inhibited organic antifreezes do not cause leakage, but neither water nor

antifreeze solution is suitable for lubrication, and when either leaks into the engine and mixes with engine oil in sufficient quantities, sludge may be formed which can cause sticking valves and piston rings, lubrication failure, and even serious damage if engine operation is continued. This applies particularly to winter operation when the coolant is not as readily removed from the crankcase as during warm weather. Because of their higher boiling points, glycol

solutions are not as readily removed by alcohol solutions.

Leakage of coolant into the engine can be avoided by inspecting the cylinder head joint periodically to make sure that the gasket is in good condition and that the cylinder head bolts are tightened in accordance with the engine manufacturer's directions. Cracked or porous castings that would permit internal leakage of coolant should be promptly replaced.

The Light-Weight Cone for Penetration of Soft Greases

Report from Section II on Consistency Measurements of Technical Committee G on Lubricating Greases of Committee D-2 on Petroleum Products and Lubricants

Prepared by L. C. Brunstrum¹

EARLY work on adapting the penetrometer to semi-fluid greases was accomplished by reducing the cone weight by counterbalancing.² During 1941–1942 the National Lubricating Grease Institute Technical Committee under the chairmanship of Carl W. Georgi investigated means of classifying and testing semi-fluid greases at the request of the Army Supply Services.³ The following year under the chairmanship of H. L. Moir, 19 laboratories participated in cooperative tests and proposed a classification of four grades based on the A.S.T.M. penetration method⁴ by use of a 30-g. cone assembly.⁵ During 1945, 13 laboratories cooperating under A.S.T.M. Technical Committee G on Lubricating Grease, Section II on Consistency Measurements, of Committee D-2 on Petroleum Products and Lubricants, submitted data on 30 and

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

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² Harry Levin and Charles J. Schlagel, "Consistency Test for Lubricating Greases. Counterbalance and Modification for Soft or Liquid Greases," *Industrial and Engineering Chemistry, Analytical Edition*, Vol. 13, May 15, 1941, pp. 295–297.

³ Carl W. Georgi, "Technical Subcommittee Report on the Tentative N.L.G.I. Classification of Semi-Fluid Greases," *The Institute Spokesman*, July, 1942.

⁴ Tentative Method of Test for Consistency of Lubricating Grease and Petrolatum (D 217-38 T), 1939 Book of A.S.T.M. Standards, Part III, p. 603. Revised in 1944 (1946 Book of A.S.T.M. Standards, Part III-A, p. 846) and 1947 (1947 Supplement, Part III-A, p. 139). Adopted as standard in 1948, to be published in the 1948 Supplement to the A.S.T.M. Book of Standards, Part III-A.

⁵ "Report on Light Weight Penetrometer Cone Standardization Tests," H. L. Moir, Chairman, November, 1943.

TABLE I.—PERCENTAGE OF 40 COMMERCIAL SAMPLES FALLING WITHIN INDICATED LIMITS.

Penetrometer Range	150-g. Assembly	50-g. Assembly	30-g. Assembly	25-g. Assembly
Under 275.....	0	0	17.5 ^b	17.5 ^b
275–300.....	0	12.5 ^b	10.0	15.0
300–325.....	0	5.0 ^b	17.5	25.0
325–350.....	0	20.0	35.0	27.5
350–375.....	17.5	30.0	10.0	10.0
375–400.....	5.0	17.5	10.0	5.0
400–440.....	15.0 ^a	2.5 ^a	0	0
Too fluid.....	62.5	12.5	0	0

^a Some penetrometers will not measure depths exceeding 400.

^b These greases are sufficiently stiff to be classified as N.L.G.I. No. 0.

40-g. cone penetrations.⁶ It is the purpose of this report to summarize the activities of these three programs.

It was recognized from the beginning that penetrations can provide nothing more than standardization of a given brand or at best of similar types of grease, that two or more products of the same penetration may not provide identical service, and that two products that provide satisfactory performance need not have the same penetration. However, because of the specialized nature and variety of the instruments being used on soft greases, the difficulties of providing wide distribution of any one of these and because of the general availability and proven utility of the A.S.T.M. penetrometer for both regular and soft greases, this instrument was selected for development of a tentative N.L.G.I. classification of semi-fluid products.

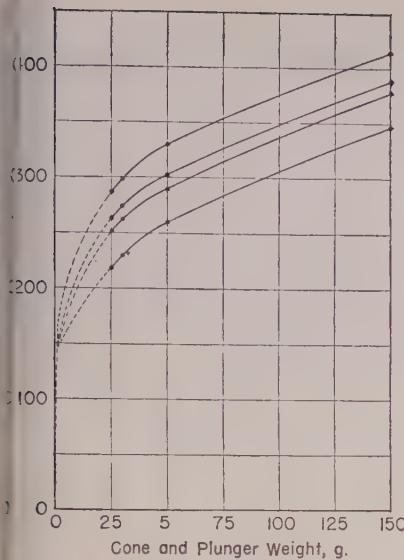
Table I illustrates the need for this classification and indicates that a cone assembly weight (total moving weight) of about 25 to 40 g. is desirable from the

⁶ Summary Report on Cooperative Test Program on Consistency of Test Methods, A.S.T.M. Technical Committee G, Section II, on Grease Consistency Test Methods, December, 1945.

standpoint of covering the range. Forty of the commercial semi-fluid products investigated may be tested with 30-g. assembly or are hard enough to fall within the N.L.G.I. No. 0 class. At least 18 per cent of the products are too soft to test with a 50-g. assembly.

Actual penetration data on food greases using four different cone assembly weights is shown in Fig. Since a cone of zero weight would cause no penetration, the curves of weight versus penetration must pass through the origin. To avoid poor reproducibility caused by small variations in cone weights on the steep portion of the curves it is obviously necessary to select the heaviest assembly that will do the job. Because it is undesirable to reduce the weight of the well-established 150-g. assembly, the light cone must be capable of testing samples just softer than N.L.G.I. No. 0.

It was recognized that cone weights about 30 g. approach the weight where floating occurs at 400 penetration, and it was feared that "errors" and poor reproducibility would result. However, the test is entirely arbitrary and it was decided to accept the "errors" if repre-



g. 1.—Relation of Penetration to Cone Weight.

reducibility was satisfactory as determined by a test program. Perhaps it should be pointed out that floating always acts with the resistance of the grease to oppose penetration and that this is satisfactory for this arbitrary test whenever the buoyancy is not an objectionably large proportion of the total resistance to penetration. Excessive buoyancy would prevent use of the test whether reproducibility was good or poor because it would tend to make the test insensitive. While the cooperative data shed no light on this problem, it can be reported that the 30-g. assembly has provided the Standard Oil Co., and undoubtedly others, with satisfactory control of several soft greases for a number of years.

In evaluating the results of the two test programs the following must be considered: (a) reproducibility with the 150-g. assembly was not all that could be desired, (b) five laboratories working with different equipment but in one room so that they could agree on a common technique found that their reproducibility was very much better than the general surveys, and (c) the A.S.T.M. method has been rewritten more adequately to define the technique. In all probability a new program using either the 150- or 30-g. cones would provide better reproducibility. Therefore the 30-g. results must be compared with reproducibility of the standard 150-g. results of the same period. If equal or better, the 30-g. cone should be considered satisfactory as far as weight is concerned.

In the N.L.G.I. program 19 laboratories cooperated on a series of eight samples which include four calcium, two

aluminum, and two soda products. One of the lime greases was too soft for the instrument but served to define this limit. Three greases were used in the A.S.T.M. 30 and 40-g. tests by 13 laboratories. These may be compared with five samples of the most recent general A.S.T.M. survey by 18 laboratories. The results of these cooperative test programs are shown in Table II. It

TABLE II.—SUMMARY OF THREE TEST PROGRAMS.
13 to 19 Laboratories Cooperating. Based on Worked Penetration.

Program	Sample	Percentage of Laboratories Within the Range of Penetration Spread		
		10 Point Spread	20 Point Spread	30 Point Spread
A.S.T.M. 150 g.	GII-1	53	83	92
	GII-2	68	95	100
	GII-3	62	86	97
	GII-4	56	89	100
	GII-5	34	83	100
	Av.	55	87	98
A.S.T.M. 40 g.	GII-1	50	81	88
	GII-5	75	94	100
	GII-6	75	94	94
	Av.	67	90	94
A.S.T.M. 30 g.	GII-1	18	59	82
	GII-5	65	76	88
	GII-6	59	82	100
	Av.	44	72	93
N.L.G.I. 30 g.	L-1	...	89	100
	L-2	...	78	89
	L-4	...	...	100
	A-1	...	94	100
	A-2	...	84	100
	S-1	...	...	89
	S-2	...	94	100
	Av. ....	...	< 88	97

should be pointed out that most of the penetrations fall within the ± 3 per cent limits prescribed by A.S.T.M. Method D 217-38T² for a single laboratory. A brief study of Table II reveals that either the 30-g. or 40-g. assembly yields about the same degree of reproducibility as the 150-g. assembly. It is significant that the 30 and 40-g. tests were made only on products of over 300 penetration where the reproducibility is poorest, whereas the 150-g. tests covered a wider range.

The final conclusions of the A.S.T.M. and N.L.G.I. programs are included in their entirety:

A.S.T.M. Program:

"1. Inter-laboratory reproducibility with 30 and 40-g. cones is not as good as that with the standard 150-g. cone, although the difference is not too great. With more experience, it seems possible that reproducibility could be of the same order. Comments have been made that cones light enough to be suitable for the wide range of commercial semi-fluid greases may have inherent errors due to buoyancy effects. With the reference samples used in this cooperative program, this does not seem to be a factor since there are no significant differences

indicated between the 30 and 40-g. cones as to test repeatability or reproducibility.

"2. The data secured in this test program confirm and agree with a similar program conducted by the Technical Committee of the National Lubricating Grease Institute in 1943.

"3. Test repeatability with the light-weight cones is comparable with that of the standard heavy cones. Except for the slightly poorer inter-laboratory test reproducibility, the cooperative tests with the light-weight cones show the same general characteristics as those with the 150-g. cone.

"4. If there is sufficient agreement that a standardized cone penetration test for semi-fluid greases is desirable, it appears the 30-g. cone, or possibly the 40-g. cone, can be adopted with reasonable satisfaction."

N.L.G.I. Program:

The following is the "Proposed N.L.G.I. Classification of Semi-Fluid Greases:

Grade	Worked Consistency (Modified A.S.T.M. Penetration with 30-g. cone). See Note 1
F-4	270-300
F-3	300-330
F-2	330-360
F-1	360-385

"Note 1.—Method of test is identical with A.S.T.M. D 217 - 38T⁴ for consistency of non-fluid greases except for the following modifications:

(a) The total moving weight of the cone and plunger rod attachment shall be 30 g. instead of 150 g. This weight is critical and appreciable deviation will cause errors in penetration measurements.

(b) The grease worker cup of 3 in. inside diameter or a sample cup of 3 in. I.D. must be used for all tests with the 30-g. cone. Use of samples cups of larger diameter will result in large errors in penetration measurement.

"Note 2.—The proposed N.L.G.I. Classification of Semi-Fluid Greases is based on consistency only and is not intended to evaluate factors of apparent viscosity, type of soap, mineral oil constituent, or quality. Some types of semi-fluid lubricants are more nearly similar to viscous fluids than to plastic greases in which case consistency measurements may be misleading if other properties are taken into consideration.

"Specifically, it is possible to formulate two semi-fluid greases of substantially identical penetration by the 30-g. cone but of markedly different apparent viscosities. Such a condition is related to the viscosity of the mineral oil constituent and type of soap base used in formulation.

"Accordingly, consistency measurement alone of semi-fluid greases will not serve to define their service performance properties, and other factors such as mineral oil viscosity, type of soap, etc., must also be defined.

"Note 3.—Some types of semi-fluid greases become markedly softer after the 60 stroke working in the A.S.T.M. Grease Worker. The degree of change in some instances may be equal to a change of one or two N.L.G.I. grades. While the worked penetration is specified for the N.L.G.I. Classification in order to assure better agreement and reproducibility in the handling and testing of grease samples, this requirement may be undesirable in some circumstances.

"In instances where the unworked consistency is of greater importance than the worked consistency, the proposed N.L.G.I. Semi-Fluid Grease Classification may be used with the suffix 'unworked'."

Photoelectric Measurement of a Color Index of Liquid Petroleum Products

By Louis Lykken¹

SYNOPSIS

A rapid, reproducible method for the photoelectric measurement of a color index of liquid products has been developed by Subcommittee VI on Color of A.S.T.M. Committee D-2 on Petroleum Products and Lubricants.² The method depends upon measurement of transmitted light using a photoelectric colorimeter having specified characteristics and equipped with a broad-band "north sky" and narrow-band red and violet color filters. Good instrument-to-instrument reproducibility is attained by use of calibration curves prepared from glass standards chosen to approximate the spectral properties of the test material. The method is designed particularly as a specification method to replace the less sensitive A.S.T.M. Union color method³ for determining the color characteristics of lubricating oils and products having similar spectral properties. The new method is basically more sound than visual methods based on a single discontinuous series of color standards and avoids the uncertainty of the human eye.

IN MODERN commercial transactions, the color of a liquid is generally of considerable importance to both producer and consumer, mainly, because it is desirable to have a product that is pleasing to the eye and that remains consistent in appearance over a period of time. Oftentimes, color is also important because it is the only practical criterion by which the ultimate consumer can judge the quality of the material in question. Thus, the determination of color of a liquid product is necessarily of interest and concern to the producer, and, in case of specification restrictions, to the consumer.

VISUAL METHODS

The color of a liquid is appreciated by the eye in terms of its lightness, hue, and saturation. *Lightness* of the color of a nonturbid liquid is that attribute which permits it to be classified as equivalent to some member of the series of neutral colors ranging from black to perfectly clear and "colorless." *Hue* is that attribute of a color which permits it to be classified as red, orange, yellow, green, blue, purple, or an intermediate. *Saturation* is that attribute of a color which determines the degree of its difference from the neutral color of the same lightness. A customer can by looking at a liquid judge whether it has a light or dark color, whether it is reddish, yellowish, or greenish, and whether

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² Members participating in cooperative work: H. M. Hancock (*Chairman*), The Atlantic Refining Co.; D. B. Judd, Natl. Bureau of Standards; L. Lykken, Shell Development Co.; G. A. Matte, Cities Service Oil Co.; and J. B. Rather, Jr., Socony-Vacuum Oil Co.

it is close to or far from neutral. Nobody has the faculty, however, of making these judgments with high precision; so a reliable color index for liquids cannot be achieved by visual estimate alone. It is common practice to set up color standards that are visually compared with the unknown liquid in order to determine an index of the color.

If these color standards form a system such that a color match for any of the entire series of liquids under consideration may be found, a true color measurement results. The set of color standards used in the Lovibond Tintometer⁽⁴⁾† is an example. Three sets of standard color glasses—a red, a yellow, and a blue set—are used. Each set consists of 155 glasses identified by numbers assigned in such a way that the color produced by combining a No. 1 glass with a No. 2 glass produces the same color as that of glass No. 3, and so on. The apparatus is constructed so that light transmitted through the sample, contained in a special cell, may be compared with that passing through the color glasses. Various combinations of the glasses are compared with the sample until a color match is obtained. Color measurements based on visual comparisons with such standards may theoretically be made reliable and adequate. The cost of such standards, however, is quite considerable, and the expense of calibrating them so that different sets will yield identical measurements restricts their use considerably.

Sets of color standards in common use are designed for restricted series of colors varying essentially in a one-dimensional way such as the variation

[†] The boldface numbers in parentheses refer to the list of references appended to this paper.

produced by increasing the concentration of a single coloring material. There are two ways of developing such color standards. One is to select a limited number of standards duplicating as closely as possible a few well-specified colors of the range of colors to be indicated. These standards are given arbitrary identifying marks. The observer has to decide by visual comparison which standard is the closest color match for any given specimen to be tested, or he has to estimate the position of match within the color step defined by adjacent color standards. The A.S.T.M. Union Colorimeter³ is an example of this kind of collection of color standards. It employs a series of 16 glass disks that are similar in color to lubricating oils and petrolatum. The sample, contained in a specified 4-oz. bottle, is placed in the colorimeter adjacent to a vertical rack containing the colored disks, and in front of a light source in such a manner that light transmitted through the sample can be visually compared with light transmitted through one of the disks. The disks are individually compared with the sample until the closest match is found. The assigned number (1 to 8) of this disk is reported as the A.S.T.M. Union Color Number.

Another method of covering a one-dimensional series of colors is either by variation of the length of column of the sample to be tested until it matches a single color standard, or by variation of the concentration of a standard solution until it produces a match for the unknown. The A.S.T.M. Saybolt Chromometer⁴ is an example of the first plan. Light-colored materials are measured by adjusting the height of a column of the liquid being measured until its color matches a color standard produced either by a single glass disk or by a combination of two disks. The color index is an arbitrary number (+30 to -10) derived from the height of the liquid and the number of disks required to produce a color match. The Hazen

³ Tentative Method of Test for Color of Lubricating Oil and Petrolatum by Means of A.S.T.M. Union Colorimeter (D 155-45 T 1946 Book of A.S.T.M. Standards, Part III, p. 839. Also in A.S.T.M. Standards on Petroleum Products and Lubricants, October 1947, p. 104).

⁴ Standard Method of Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer (D 156-38), 1946 Book of A.S.T.M. Standards, Part III-A, p. 138. Also in A.S.T.M. Standards on Petroleum Products and Lubricants, October 1947, p. 109.

(Platinum-Cobalt) Scale⁶ is an example of the second plan. In this system, the color of a column of the liquid being tested is matched with that of an identical column of a standard solution containing a mixture in fixed proportions of potassium platonic chloride, cobalt chloride, hydrochloric acid, and water. The series of standards (0 to 500) required is prepared by dilution of a specified standard stock solution.

All of these methods have the severe limitation that they apply only to liquids whose colors are found in or very close to the one-dimensional series covered by the color standards. If the average is by discrete steps, as in the A.S.T.M. Union colorimeter, there is the added disadvantage of visual interpolation between colors. The colors of petroleum products fall fairly close to a one-dimensional series but not sufficiently close to prevent occasional readings by the A.S.T.M. Union colorimeter from being importantly uncertain. Various ways of improving the decision of setting in a visual colorimeter of this type have been considered by A.S.T.M. committees over a period of years, but none has been found adequate for the purpose and capable of incorporation in a colorimeter at reasonable cost. The chief aim of these studies has been to develop a lightness index of the color of petroleum products.

PHOTOELECTRIC METHODS FOR PETROLEUM PRODUCTS

The substitution of instrumental nonvisual means in place of visual comparative methods has been a comparatively recent development, possibly because of the apparent difficulty of replacing accepted visual methods, even though these were plainly of a gap nature. In 1933, Story and Kalichevsky(5) proposed the use of a simple photoelectric transmission method for the measurement of color of liquid petroleum products. Little consideration was given to this alternative until 1940 when Subcommittee VI of A.S.T.M. Committee D-2 began a study of a photoelectric method to replace the A.S.T.M. Union colorimeter and A.S.T.M. Saybolt chromometer methods. This work was inspired by the limited scope and precision of the visual methods, but added impetus was given in early 1942 when, owing to war conditions, it appeared likely that the supply of standard glasses for the A.S.T.M. Union colorimeter might become exhausted.

An optimum photoelectric method for the measurement of color, which is both

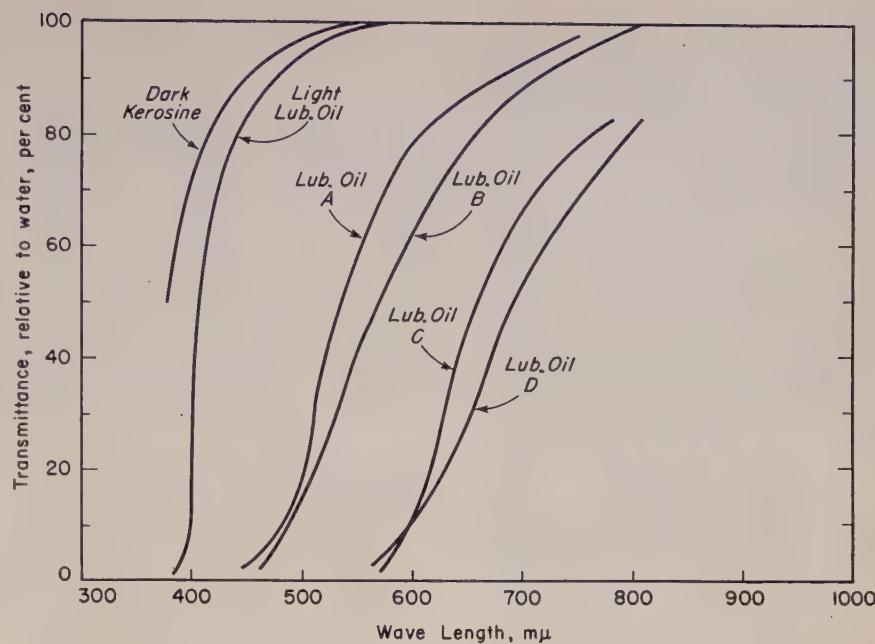


Fig. 1.—Spectral Characteristics of Typical Petroleum Products.

sound in principle and readily applicable in practice, should combine several important characteristics. The method should be simple and rapid and should be readily applicable to a wide range of liquids or liquefiable materials. The values obtained should be more reproducible than those by the present visual methods and the results should have a ready meaning in trade parlance. The method should preferably utilize one or more of the available photoelectric colorimeters of proved design, should provide some means of compensating for small changes in instrument response, and should require the use of available permanent color standards. The value obtained should give some measure of the hue of the liquid as well as the lightness of its color and should not be greatly affected by minor, inappreciable changes in spectral transmission or fluorescent characteristics of the sample. The scale used in determining the results should be a single, continuous one covering both light- and dark-colored materials, and the resulting numerical values should increase as the degree of color of the sample increases.

As illustrated by the typical spectral transmittance curves in Fig. 1, the spectral characteristics of petroleum products have a similar pattern, the transmittance gradually increasing with wave length over a limited range and the transmittance curve shifting to longer wave lengths as the color becomes darker. For oils of a given lightness, the transmittance curves sometimes intersect at some point in the general region of 550 mμ but differ in slope. This difference in slope results in some oils

showing a higher red and a lower blue transmittance than others. In other words, all oils of the same lightness have transmittance curves that intersect, but some of the curves passing through the intersection have steeper slopes than others. Thus, a characterization of the color can be obtained by measuring the transmittance at the point of intersection and at some other point as well. The first transmittance will be a measure of the lightness and the second transmittance relative to the first will be an index of the hue, the oils showing relatively high red transmittances being reddish(2,3).

The early work of Subcommittee VI of A.S.T.M. Committee D-2 culminated in 1942 with the publication as information of a Proposed Method of Test for Color of Lubricating Oil by Means of Photoelectric Colorimeter.⁷ This proposed method utilized a transmittance measurement of the sample relative to distilled water with light from a broadband "north sky" filter (Fig. 2) to indicate the lightness of the color; an additional transmittance measurement with light from a "red" filter was used to indicate the approximate hue of the color. The north sky and red transmittances were plotted on a graph similar to Fig. 3, and the sample was considered to have a "normal" color if the plotted point fell between the curves and "abnormal" color if it fell outside of the curves. The observed percentage transmittances were used without correction, and the north sky value was

⁶ Standard Methods of Sampling and Testing Lacquer Solvents and Diluents (D 268-46), 1946 Book of A.S.T.M. Standards, Part II, p. 1105. Also A.S.T.M. Standards on Petroleum Products and Lubricants, October, 1947, p. 179.

⁷ Report of Committee D-2 on Petroleum Products and Lubricants, Appendix II, *Proceedings, Am. Soc. Testing Mats.*, Vol. 42, p. 317 (1942).

reported as "color index," being 100 for colorless oils and zero for black, opaque oils. In the case of light-colored samples (color index above 96), the "violet" transmittance was determined and the color index calculated from the empirical relationship:

$$\text{Color Index} = 90 + 0.1 \text{ (violet transmittance)},$$

thus magnifying the sensitivity of the colorimetric measurement in an ideal case by a factor of ten. The method required a special colorimeter which had to meet rigid response specifications with certain colored solutions of inorganic salts and utilized a tube-type cell.

One of these instruments was cooperatively tested in 1941 by members of Subcommittee VI and other interested parties on a number of cooperative and private samples. The results of these tests indicated that the method had promise but was not fully satisfactory. The most serious objection to the original method was the absence of any means for adjusting or calibrating the instrument response which, contrary to expectations, changed from time to time. Another practical difficulty was the unavailability, for a time at least, of the specified photoelectric colorimeter.

After publication of the proposed method as information in 1942, further cooperative work was temporarily stopped because of pressure of more urgent war work. In 1944, Subcommittee VI again resumed work toward a suitable photoelectric method, using their published method as a basis. After discussion with colorimeter manufacturers and members of the National Bureau of Standards, a considerably revised version of the first proposed method was circulated in 1944 for study. After further revision, the method was tested cooperatively in 1945, in four laboratories, on a preliminary basis. The major revisions over the 1942 method were: (1) substitution of International Commission on Illumination (ICI) daylight, blue, and amber filters (1) in place of the north sky, violet, and red filters, respectively; (2) substitution of parallel-planar cells for the round cells; (3) measurement of dark samples in narrow cells instead of in regular cells after dilution with a solvent; (4) substitution of a parallel beam of light in place of the converging beam; (5) correction of the observed readings by an instrument response calibration curve for each filter, correlating the observed transmittances for certain solutions with values specified in the method; (6) relaxing the instrument response specifications tolerated by the method. The last two changes were made to permit use of several types of commercial photoelec-

TABLE I.—TYPICAL COLOR INDEX DATA OBTAINED IN THE 1946 COOPERATIVE TESTING BY SUBCOMMITTEE VI OF A.S.T.M. COMMITTEE D-2.

Oil Sample	Laboratory A		Laboratory B		Laboratory C		Laboratory D	
	Procedure 1	Procedure 2	Procedure 1	Procedure 2	Procedure 1	Procedure 2	Procedure 1	Procedure 2
S-125 ^a	36.0	36.4	35.6	36.6	42.6	43.3	41.7	41.8
S-126	46.4	46.9	46.8	46.6	49.2	48.5	46.5	47.6
S-127 ^a	20.5	20.2	20.2	21.5	21.5	21.2	20.9	17.7
S-128 ^a	93.2	92.4	93.3	92.6	92.9	93.4	93.0	91.8
S-130 ^a	2.8	2.9	—	—	3.0	2.6	2.7	—
S-131 ^a	3.9	3.6	3.5	—	3.8	4.3	4.1	—
S-133 ^a	99.9	99.9	100	100	100	100	—	—
S-134 ^a	96.5	96.6	97.1	96.9	97.1	97.4	—	—
S-135 ^a	91.4	93.3	93.7	93.2	91.8	93.4	92.3	92.2
S-136 ^a	97.9	97.8	98.6	98.5	98.7	98.7	—	—

NOTE.—Procedure 1—Color temperature of light source and galvanometer sensitivity not specified.
Procedure 2—Color temperature of light source and galvanometer sensitivity specified by adjusting the instrument to certain definite response values.

^a Samples developed varying amounts of turbidity on standing. This is considered to be the cause of the unusually high spread of the color index values found for these samples.

tric colorimeters and to allow for changes in instrument response over a period of time. The results of the preliminary tests indicated that (1) the calibration curve correction system was a valuable addition to the method, (2) the blue and amber ICI filters did not serve to distinguish as sensitively between various petroleum products as the violet and red filters, (3) liquid standards were not stable under all conditions, (4) the most reproducible results were attainable on colorimeters of the same make, and (5) that the Lumetron Model 402E photoelectric colorimeter (made by the Photovolt Corp.) was the most generally satisfactory instrument.

While the preliminary tests did not yield entirely satisfactory results, they indicated that certain additional revisions might give a reproducible method. Consequently, the method was revised again and a comprehensive cooperative test program was conducted in 1945 and 1946 to evaluate the revised method and several variations of it. The revised method differed from the preliminary intermediate method as follows: (1) the original north sky, violet, and red light filters were resubstituted in place of the ICI daylight, blue, and amber filters; (2) the Lumetron Model 402E colorimeter was specified; (3) the temperature of the sample during measurement was specified at $25 \pm 1^\circ\text{C}$; (4) the calibration curves were prepared by use of five specified iron-cobalt chloride solutions of varying lightness and having spectral properties resembling those of petroleum oils; (5) for test purposes, various modifications were specified in the procedure for adjusting the galvanometer sensitivity and intensity, or color temperature, of the lamp within wide or narrow limits of tolerance.

The cooperative test program was conducted over a period of 1 yr. and involved measurements every two or three months on approximately 12 standard color solutions and 10 typical oil samples. Some of the data obtained on the oil

samples are shown in Table I. The results of these tests demonstrated that reproducible results can be obtained over a period of time in different laboratories using the Lumetron instrument. It was found that careful control of the galvanometer response and color temperature of the light source did not appreciably increase the reproducibility of the results, the essential requirement being a series of suitable color standards from which to prepare a calibration curve. Also, the results indicated that it is preferable to measure dark samples after making a 1 to 9 dilution rather than to use a corresponding thin layer of the original sample.

The cooperative experience indicates that, while inorganic salt solutions were reasonably satisfactory as calibration standards, it was desirable to replace them with glass standards. Near the conclusion of the tests, the National Bureau of Standards made available colored glass standards having certified transmittances and spectral characteristics similar to the liquid standards. These glass standards are expected to be superior to the liquid standards for general use; consequently the method has been revised accordingly. Also, it was considered desirable to provide a means of calculating the north sky transmittance of a diluted sample to the value which theoretically would have been obtained, if possible, by direct measurement, thus affording a continuous color index scale; such a provision has been included in the final revision of the method as published as information in the 1947 report of A.S.T.M. Committee D-2.⁸

The A.S.T.M. Proposed Method for Determination of Color Index of Petroleum Products by Photoelectric colorimeter⁸ is intended for the photoelectric determination of a color index of petroleum products. It is designed particularly as a specification method for de-

⁸ Report of Committee D-2 on Petroleum Products and Lubricants, Appendix IV, *Proceedings of the Am. Soc. Testing Mats.*, Vol. 47, p. 307 (1947); also A.S.T.M. Standards on Petroleum Products and Lubricants, October, 1947, p. 615.

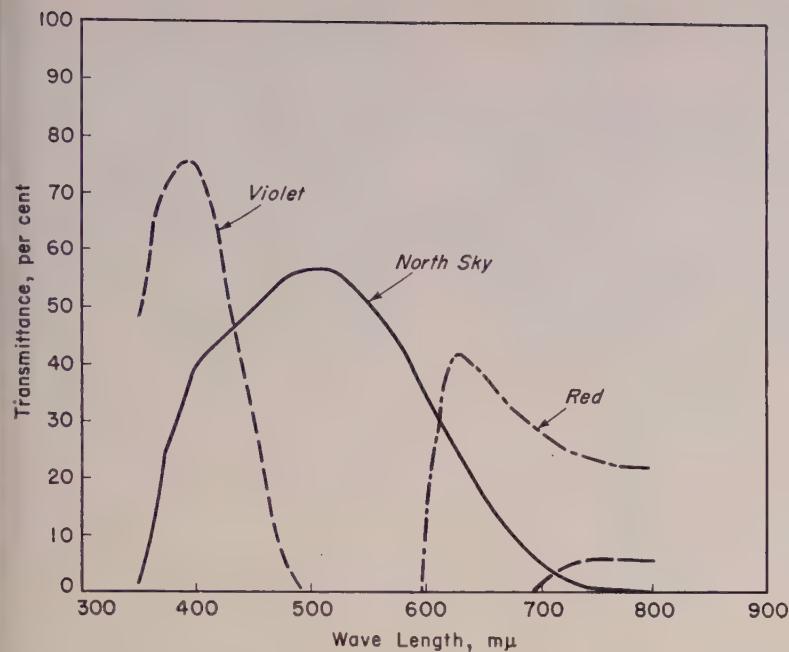


Fig. 2.—Spectral Transmittance Curves of North Sky, Violet, and Red Filters.

dmining the color characteristics of oiling oils and products having similar spectral properties. It is not applicable to samples that show a turbidity at room temperature nor to materials whose spectral properties differ markedly from sample to sample.

The proposed method specifies no particular type or kind of photoelectric colorimeter but specifies that it must be adjustable to meet certain specification limits, within liberal tolerances. These tests consist of measuring the north sky, violet, and red transmittances of a series of colored glass standards obtainable with certified values from the National Bureau of Standards. If the observed and certified transmittances do not differ by more than certain specified tolerances when proper galvanometer sensitivity has been attained, the colorimeter is suitable for use; the deviations found for five standards that resemble oils in color are plotted to form a curve for use in correcting the observed north sky, violet, and red transmittances. Using a 20-mm. light path, the observed north sky transmittance (in percentage units) relative to water is determined for the sample, and the appropriate adjustment is applied to obtain the "north sky transmittance" of the sample. If this value falls between 3.0 and 95.0, we say:

Color Index = North Sky Transmittance

For north sky transmittances above 95 per cent, the observed violet transmittance is obtained and, by means of the calibration graph, the "violet transmittance" is calculated; the color index

for calculated values of color index below 0.1, where H is the "north sky transmittance" of the diluted sample. By this means, a scale is obtained which is essentially continuous from 0 to 100 and which is sensitive to both light- and dark-colored materials. When information regarding hue is desired, the observed red transmittance is obtained and the red transmittance is calculated by means of the calibration graph, and the north sky and red transmittances are plotted in a graph similar to Fig. 3; the sample is considered of normal hue if the plotted point falls between the two curves.

The repeatability and reproducibility were found to be approximately ± 0.5 and ± 1 color index units, respectively; the corresponding values for light-colored liquids with color index above 95.0 per cent were 0.1 and 0.2, respectively. This precision was obtained by using Lumetron Model 402E colorimeters in conjunction with inorganic liquid standards for testing and calibrating the instrument response and making no special effort to use exactly the same operational technique. While only incomplete data are available for tests with N.B.S. certified glass color standards, it is expected that their use will give precision of the same order. With commercial photoelectric colorimeters other than the Lumetron instrument, the reproducibility and repeatability were not as satisfactory, being 4 and 2 color index units, respectively.

The proposed color index values were correlated with A.S.T.M. Union color numbers by determining these values for four different sets of approximately 100 oil samples, of varying color, in four different laboratories; the samples were

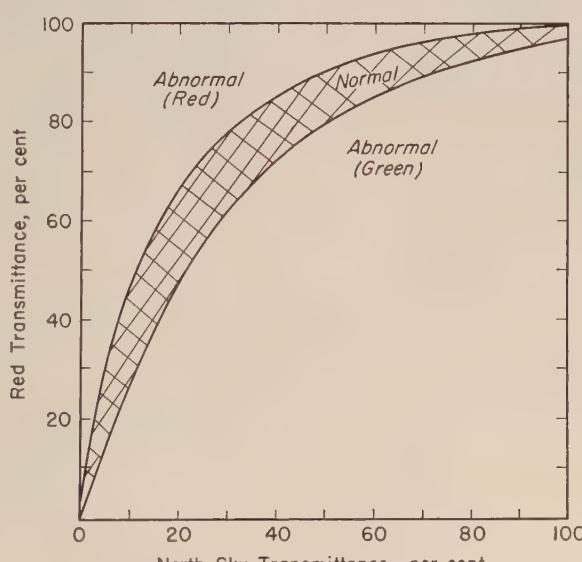


Fig. 3.—Region of Normal Color.

chosen to be representative of all types of commercial petroleum products including materials of abnormal as well as normal hue. The correlation found was similar to that shown in Fig. 4 which gives the results found in one laboratory only. In general, it was found that the color index by the proposed photoelectric method bears a good relationship with the visual A.S.T.M. Union color number, being reliable in most cases within the precision of the visual method; however, no exact relationship was established, mainly on account of the oils with abnormal colors. No general and definite correlation was expected for those materials not resembling the color of the calibration standards. The occasional wide deviations of particular samples from the average curve was considered to be largely a result of the inherent discontinuity of the A.S.T.M. Union color numbers and of the difficulty of visually matching samples that differ in hue from the standard color disks. While insufficient data are available to correlate color index with A.S.T.M. Saybolt color values, it was concluded that a similar correlation is possible.

The correlation curve (Fig. 4) between A.S.T.M. Union color numbers and photoelectric color index makes possible a comparison of the precision of the two methods. The average reproducibility of the visual (Union) method is approximately 0.25 Union color numbers or 5 color index units. In comparison, the reproducibility of the photoelectric (color index) results using the Lumetron instrument is 1 color index unit or approximately 0.05

Union color numbers; for different makes of photoelectric colorimeters, the reproducibility is approximately 4 color index units or 0.2 Union color numbers. Thus, the proposed photoelectric method appears reproducible to one-twentieth of the average difference between two adjacent Union color disks under favorable conditions and to one-fifth of this difference in the most unfavorable case.

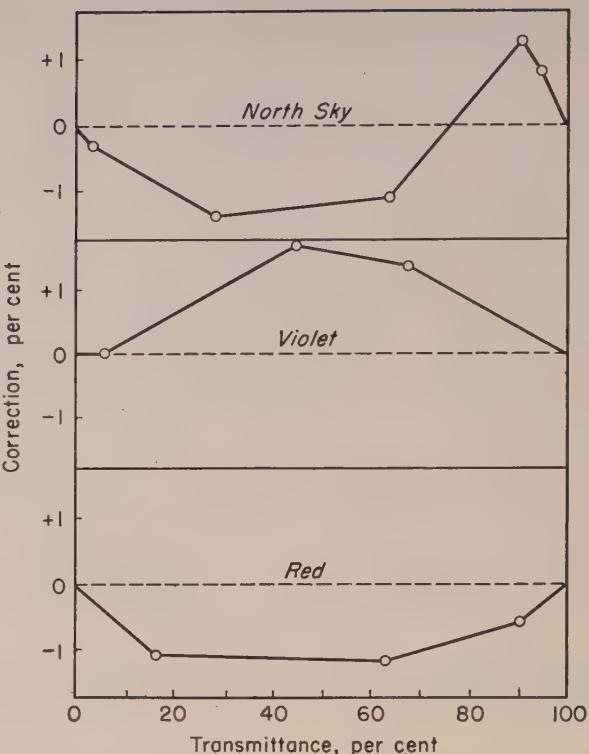


Fig. 5.—Typical Calibration Curves for North Sky, Violet, and Red Filters.

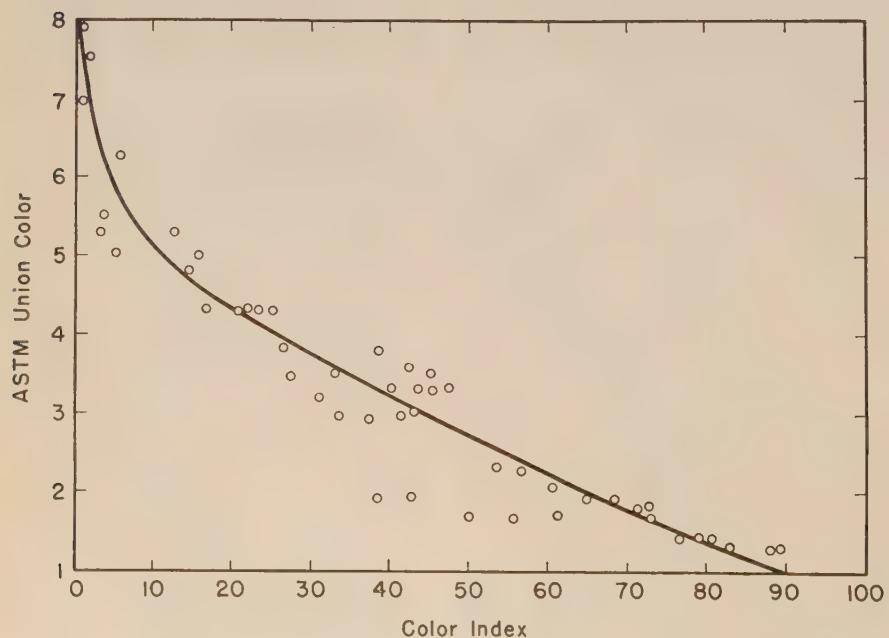


Fig. 4.—Correlation of Photoelectric Color Index with A.S.T.M. Union Color.

DISCUSSION

A serious difficulty encountered in the development of the photoelectric color index method was the establishment of suitable basic instrument specifications. An additional related problem was the development of proper technique of instrument operation. The early method published as information in 1942⁷ utilized a rigidly specified, converging beam photoelectric colorimeter. Since difficulty was continually experienced in obtaining the only commercial colorimeter intended for use with this method, Subcommittee VI felt that it was desirable to avoid rigid specification of a special instrument, if that was possible, in order to get a more versatile and better received method; consequently, the instrument specifications were liberalized as much as was safely possible. In addition the original instrument intended for use with this method was found to change with use so that the specified responses were no longer attainable; also, it was expected that difficulty would arise from the specified converging beam and round cell in that variations of refractive index would affect the transmittance reading. The solution to these objections was found in using calibration (correction) graphs, allowing wider tolerances in the instrument response specifications, and specifying parallel beam light and parallel-planar cells.

The calibration graphs correct for changes in instrument response since

they are prepared by measuring the transmittance of the various standards with the north sky, violet, and red filters in the particular instrument and under the identical conditions that are used in measuring the test materials. The deviations between the observed and certified transmittances are plotted as corrections to be applied to observed reading for samples. Three calibration graphs are prepared, one for each of the three filters, by plotting the corrections against the observed transmittances and connecting each plotted point to its neighbor with a straight line. Figure 5 shows typical calibration curves. In practice, the observed transmittance of a particular sample is corrected by reading the graph at the observed transmittance and applying the corresponding correction.

The early methods specified the use of certain standard inorganic salt solutions which exhibited colors of varying lightness and hue over the visible spectrum. In order for the instrument to meet specifications, the transmittances obtained with specified filters for these standard solutions had to meet the specified transmittances within narrow limits. As previously mentioned, the method was subsequently revised to allow the use of as many as possible of the various filter photometers commercially available; however, the revision still utilized a slightly augmented series of standard inorganic salt solutions for testing the instrument response. During preliminary testing, it was found that many colorimeters which failed to pass the original, stringent specifications became acceptable for use provided their observed responses were correlated to the certified response of suitable standards by means of calibration curves. This correction system met with the best success when applied to the Lumetron 402E colorimeter, which has a fairly high degree of adjustability. While reasonably effective with this instrument, the correction system failed to compensate fully for differences in instrument responses found with various individual examples of the Klett-Summerson photoelectric colorimeter (Model 900-3), the Fisher Electrophotometer (a-c. model), and the Hellige-Diller photoelectric colorimeter (Model 400). However, this system was found to compensate adequately for response changes that occur in any particular colorimeter.

In using the inorganic salt solutions

TABLE II.—COMPARISON OF A.S.T.M. UNION COLOR AND PHOTOELECTRIC COLOR INDEX OF TYPICAL PETROLEUM PRODUCTS.

Sample	A.S.T.M. Union Color	Color Index	
Straight run gasoline.....	1-	98.2	Abnormal
Third structure gasoline.....	1-	99.3	Abnormal
Light kerosine.....	1-	99.8	Abnormal
Dark kerosine.....	1-	96.6	Abnormal
Light turbine oil.....	1-	96.2	Abnormal
Pale oil.....	2-	71.6	Normal
Diesel lubricating oil.....	2-	69.5	Normal
Lubricating oil.....	3-	54.5	Normal
Stove oil.....	2½	50.0	Normal
Lubricating oil.....	3+	47.6	Normal
Lubricating oil.....	3½	42.0	Normal
Lubricating oil.....	4-	29.2	Normal
Red oil.....	5+	12.8	Normal
Aircraft lubricating oil.....	6+	5.7	Normal
Lubricating oil.....	7-	2.2	Normal
Transmission oil.....	8	0.41	Normal
Diesel lubricating oil.....	3½ + Dil	0.25	Normal
Fuel oil.....	5 + Dil	0.035	Normal

as color standards, some difficulty was encountered in obtaining repeatable observed transmittance values because of the slight tendency of the solutions to be unstable, particularly with respect to temperature changes and weathering during handling. Consequently, it was decided to use the more convenient permanent glass standards having spectral transmission characteristics approximating the liquids previously used. The use of these glass standards, supplied by the National Bureau of Standards, has not been extensively tested, but preliminary tests have indicated that they will be satisfactory.

While the method published does not have all the optimum features, earlier mentioned as desirable in a photoelectric method, it is simple, rapid, and applicable to petroleum oils. The color index corresponds closely to the daylight transmittance of the sample; hence, the values decrease numerically as the liquid becomes darker in color. It is reproducible (at least on one commercial instrument) and provides a reasonably continuous system covering the complete range of color intensities, from opaque to colorless liquids. Also, it is applicable to waxes and materials that melt at approximately 40 C. or lower. It is basically more sound than common visual methods and is of particular value as a specification or control test method for lubricating oils since it provides a more precise evaluation of color density and hue than the common visual methods now employed. Table II gives a comparison of results obtained by the proposed photoelectric color index method and by the A.S.T.M. Union color method for a variety of typical petroleum products.

The proposed color index method is not fully applicable as written, to liquids

whose spectral characteristics differ appreciably from typical petroleum products, but it is useful in testing many types of materials provided all the samples in the group have similar spectral properties. There is no reason to believe that it cannot be used meaningfully in the latter case as well, provided suitable standards and calibration curves are prepared. For liquids differing considerably in spectral character from petroleum products, it is expected that the use of filters different from the north sky, violet, and red filters will be advantageous. The method is not applicable where a precise measure of hue is desired.

Acknowledgment:

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Report of the A.S.T.M. Task Group Studying the Wyzenbeek Precision Wear Test Meter*

By Seaman J. Tanenhaus¹ and Gerald Winston²

SYNOPSIS

A study of the Wyzenbeek Precision Wear Test Meter was made to determine its suitability for use as a standard instrument for determining the abrasion resistance of textiles. The results of two interlaboratory tests, which included consideration of end points and abradants, indicate that the severity of abrasion among the units is too variable to permit the use of the Wyzenbeek apparatus for establishing interlaboratory standards. Individual instruments were found to be sufficiently precise for evaluating differences among fabrics. A number of suggestions for improving the technique of operation are included.

A PRINCIPAL objective of the Task Committee on Abrasion Testing (under Subcommittee B-1 on Methods and Machines, Section 1 on Methods of Testing, of A.S.T.M. Committee D-13 on Textile Materials) is the examination of various commercial abrading instruments to determine their suitability for use in establishing standard methods. Task groups have been formed within the committee to study the Taber Abrader, the U. S. Testing Co.'s abrader and the Wyzenbeek Precision Wear Test Meter, as a canvas had indicated that these instruments are in widest use (1).³ The present paper discusses the work of the task group investigating the Wyzenbeek apparatus (Fig. 1). This machine is manufactured by Wyzenbeek and Staff, Inc., Chicago, Ill.

Methods of evaluating the extent of damage fall into two classes, namely, those utilizing visual evidence of degradation, generally employed when appearance is a factor (woolen outerwear, plush, etc.), and those considering the change in some mechanical characteristic, usually breaking strength, after a given period of abrasion. The latter method is used primarily for utility fabrics (work garments, webbings, etc.). Abradants are of many types, including metal screening, abrasive cloths and papers, standard fabrics, and the test cloth itself. Statistical control is used by some technicians. Some operators employ the vacuum device furnished by the manufacturer to remove the detritus,

others use a brush for this purpose, and the rest do neither. A choice of operating conditions in so far as load, tension, and cycles of abrasion are concerned is possible by virtue of the construction of the instrument.

Because of the many possible variations in technique, it was decided first to ascertain satisfactory conditions of load and tension for performing the test on a readily available cloth and using a

single machine. After standard abrading conditions for this unit were selected, a test was initiated to determine the consistency of results among a number of instruments. Two types of fabrics were used as test cloths to determine the adequacy of subjective methods for estimating end points. The results of this interlaboratory study exhibited a high degree of variation. As this might have been caused by a lack of precision in the subjectively determined end points, it was deemed advisable to conduct a second interlaboratory Wyzenbeek test, using an objective end point by ascertaining the discriminatory faculty of the instrument with regard to ranking a number of test fabrics.

PRELIMINARY STUDIES

Tension, Load, and Cycles:

The Wyzenbeek instrument permits



Fig. 1.—Wyzenbeek Precision Wear Test Meter.

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³ The boldface numbers in parentheses refer to the list of references appended to this paper.

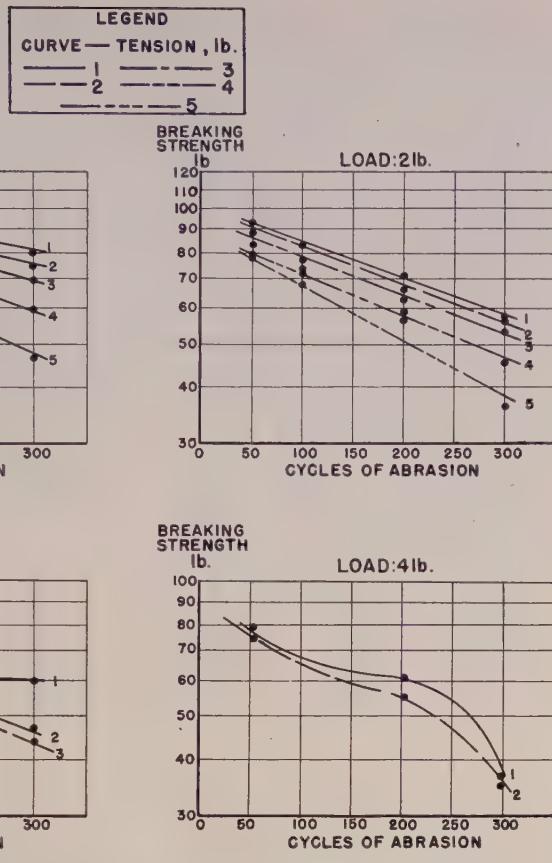


Fig. 2.—Effect of Tension on Breaking Strength at Various Loads. Wyzenbeek Precision Wear Test Meter.

NOTE:—Breaking Strength of Unabraded Herringbone Twill: 12103 lb.

the test specimen to be subjected to tensions ranging from 1 to 6 lb. and to compressional loads of from 1 to 5 lb. over 4 sq. in. of abraded area by means of two independent series of adjustable cantilever clamps. The specimen is forced by a rubber pad against an oscillating curved abrasive surface for the desired number of cycles. Three or four specimens may be tested simultaneously; depending upon the Wyzenbeek model used.

The apparatus used for determining satisfactory values of the parameters of tension, load, and length of abrasion for a particular fabric was a four-arm machine whose drum oscillated at the rate of 90 cycles per minute. The vacuum device had been removed for ease of operation. No. 320 Aloxite cloth was employed as the abradant and was changed after each run. Before testing, care was taken that each specimen was free of loose threads, but no attempt to remove detritus was made during the course of the runs. The fabric selected was an 8.5-oz. vat-dyed herringbone twill. The loss in warp tensile strength after warpwise abrasion was chosen as the measure of abrasion resistance. Control-chart technique was employed to determine homogeneity of results from the four test arms and statistical

conformance of the operator and of the tensile tester. The specimens were abraded under several tensions and loads for various cycle stages.

The results, presented graphically in Fig. 2, indicate that, within limits, semi-logarithmic relationships exist between the amount of abrasion and the loss in breaking strength. A satisfactory end point may be obtained by choosing any combination of values for the parameters of load, tension, and cycles of abrasion which lie within these limits.

End Points and Abradants:

Once satisfactory operating conditions for a given fabric were ascertained by use of an objective end point, the next step was to investigate a method employing visual end points. This latter method (5) consists of abrading a $2\frac{7}{8}$ by 9-in. specimen folded in "S" fashion to $1\frac{7}{8}$ by 9 in. to simulate edge abrasion and $1\frac{7}{8}$ by 9-in. flat strips to simulate plane wear. The number of cycles required to reach the following end points is noted:

A—First Wear.—Any radical disturbance of surface, as fuzzing, scuffing, or pilling.

B—First Rupture of Yarn.—Any rupture visible with a pick glass.

C—Threadbare.—The detachment of yarn or yarns parallel to the long direction of the specimen as a

TABLE I.—NUMBER OF CYCLES TO REACH FIRST RUPTURE AND THREADBARE END POINTS. PRELIMINARY PHASE.
(Load: $2\frac{1}{2}$ lb. Tension: 2 lb.)

End Point ^a	Warp		Filling		Warp Folded		Filling Folded	
	Cycles	Per cent ^b	Cycles	Per cent ^b	Cycles	Per cent ^b	Cycles	Per cent ^b
10.5-OZ. WOOL SERGE Fabric as Abradant								
A.....	9 890	7	8 750	7	7 600	7	5 570	7
B.....	113 100	84	110 550	83	89 800	86	62 390	84
C.....	135 400	100	120 700	100	103 650	100	74 600	100
No. 320 Aloxite as Abradant								
A.....	75	50	50	38	30	43	25	42
B.....	130	87	110	84	60	85	50	85
C.....	150	100	130	100	70	100	60	100
No. 400 Aloxite as Abradant								
A.....	80	36	65	34	40	42	30	40
B.....	180	82	150	79	75	79	60	80
C.....	220	100	190	100	95	100	75	100
No. 500 Silica as Abradant								
A.....	120	41	90	43	55	46	50	45
B.....	250	86	170	81	100	83	90	82
C.....	290	100	210	100	120	100	110	100
22-OZ. WOOL SERGE Fabric as Abradant								
A.....	16 080	6	15 040	6	14 400	6	12 890	6
B.....	234 160	93	232 700	95	232 080	98	201 150	90
C.....	251 250	100	246 100	100	236 200	100	222 650	100
No. 320 Aloxite as Abradant								
A.....	270	53	210	55	110	58	60	40
B.....	390	76	300	79	150	79	100	67
C.....	510	100	380	100	190	100	150	100

^a A = First wear. B = First rupture. C = Threadbare.

^b Percentage = $100 \times \frac{\text{Cycles to reach given end point}}{\text{Cycles to reach end point C}}$

result of multiple rupture of crosswise yarns.

For this phase, a 10.5-oz. wool serge was abraded both flat and folded in the warp and filling directions using the following abrasants: the fabric itself, No. 320 Aloxite, No. 400 Aloxite, and No. 500 silica cloths. A sample of 22-oz. serge was tested similarly, except that the last two abrasants were omitted. The number of cycles required to reach each end point and the ratios of cycles for end points *A* and *B* to cycles for end point *C*, expressed as percentages, are presented in Table I.

The results of this part may be summarized as follows:

1. As observation of surface disturbance is entirely subjective, wide variation in results using end point *A* may be expected.

2. The ratio of the cycles for end point *B* to the cycles for end point *C* appears to be fairly constant, regardless of specimen or abrasant.

3. For heavier textiles, the use of the test fabric as the abrasant necessitates an excessively long period of abrasion to reach a satisfactory end point.

FIRST INTERLABORATORY TEST

Before a decision could be reached as to the applicability of the Wyzenbeek Precision Wear Test Meter to a standard procedure, it was necessary to ascertain whether instruments in different laboratories were potentially capable of yielding reproducible and consistent results. It must be noted that although several articles have been written about this apparatus (2, 4, 5), no broad attack on the problem of interlaboratory correlation has been reported. A test was therefore formulated to determine the internal consistency of various instruments and the reproducibility of interlaboratory results. The cooperating agencies were furnished samples of 8.5-oz. cotton herringbone twill and 10.5-oz. wool serge, two commonly used abrasants (No. 320 Aloxite cloth and No. 0 emery metallographic paper) and a test plan. The plan detailed the conditions of load and tension, indicated how to prepare the specimens and how often to observe the progress of the abrasion, and defined the visual end points. The end points chosen were: *A*, first wear; *B*, first rupture; and *C*, threadbare; as described previously.

Adequate returns were received from ten laboratories. The data for the first wear end point were so scattered as to show that this end point is meaningless for purposes of interlaboratory comparison. The values for the other end points, which are shown in Table II,

TABLE II.—CYCLES TO REACH END POINTS FOR 10.5-OZ. WOOL SERGE.
FIRST RUPTURE END POINT *B*

No. 0 Emery Paper								No. 320 Aloxite Cloth							
Warp		Filling		Warp Folded		Filling Folded ^a		Warp		Filling		Warp Folded		Filling Folded	
Lab.	n	Lab.	n	Lab.	n	Lab.	n	Lab.	n	Lab.	n	Lab.	n	Lab.	n
H	830	H	1210	H	256	I	263	I	225	G	228	F	87	C	100
I	638	I	638	C	240	C	260	F	224	I	220	C	80	F	75
E	580	E	620	I	238	H	256	H	210	F	218	H	62	H	64
C	540	G	558	F	203	F	200	C	180	H	178	I	50	G	52
D	540	D	500	G	170	G	168	D	165	C	160	L	50	I	52
G	478	C	480	L	170	K	158	G	158	D	120	G	46	L	50
L	450	L	390	K	142	D	140	L	120	L	120	D	45	D	45
F	428	F	355	D	140	E	110	E	80	J	110	E	30	K	32
J	221	J	355	E	100	J	99	K	74	E	100	J	28	E	30
K	218	K	218	J	84			K	59	K	82	K	28	J	28

THREADBARE END POINT *C*

No. 0 Emery Paper								No. 320 Aloxite Cloth							
Warp		Filling		Warp Folded		Filling Folded		Warp		Filling		Warp Folded		Filling Folded	
Lab.	n	Lab.	n	Lab.	n	Lab.	n	Lab.	n	Lab.	n	Lab.	n	Lab.	n
I	1200	H	1844	I	538	C	720	F	314	I	305	F	124	C	140
H	1184	I	1200	C	520	I	388	H	298	C	280	C	120	I	105
C	1080	C	1100	H	306	H	280	C	280	F	276	I	95	F	102
D	900	L	800	L	280	F	278	I	250	G	270	G	92	H	92
L	890	D	780	F	279	G	272	D	235	H	250	H	90	G	90
E	700	E	700	G	266	L	260	G	196	D	195	L	70	L	70
G	604	G	696	D	220	D	240	L	150	L	170	D	60	D	60
F	596	F	506	E	170	K	186	E	140	J	168	J	56	J	54
J	413	J	474	K	166	E	170	J	102	E	140	E	50	E	50
K	218	K	218	J	136	J	136	K	76	K	82	K	36	K	36

^a Laboratory L value not received in this case.

were of sufficient consistency to permit analysis. As the data for the cotton and the wool fabrics exhibit similar tendencies, only those of the latter fabric are shown. Cursory examination of the data indicates that the number of cycles of abrasion required to reach a described visual end point varies widely, indicating slight agreement among laboratories. However, a closer study shows that some agencies rank consistently high whereas

others rank consistently low for end points *B* and *C*. The data for end points *B* and *C* were arrayed to allow determination of the rank correlation coefficients (Spearman's ρ) for the ten laboratories with the following test variables:

- (a) Directions of abrasion.
- (b) Abrasants.
- (c) End points.

TABLE III.—RANK CORRELATION COEFFICIENTS^a FOR TEN INSTRUMENTS. FIRST INTERLABORATORY TEST.

BETWEEN DIRECTIONS OF ABRASION^b

Abradant	First Rupture End Point versus Threadbare End Point							
	W versus F		WF versus FF		W versus F		WF versus FF	
	Serge	HBT	Serge	HBT	Serge	HBT	Serge	HBT
Emery.....	0.96	0.79	0.95	0.82	0.98	0.93	0.94	0.60
Aloxite.....	0.77	0.25	0.94	0.92	0.82	0.67	0.95	0.74

BETWEEN ABRADANTS

Fabric	No. 0 Emery versus No. 320 Aloxite							
	First Rupture End Point				Threadbare End Point			
	W	F	WF	FF	W	F	WF	FF
Serge.....	0.58	0.47	0.85	0.88	0.59	0.56	0.77	0.94
Herringbone twill.....	0.49	0.28	0.90	0.92	0.38	0.55	0.52	0.88

BETWEEN END POINTS

Fabric	First Rupture versus Threadbare							
	Warp		Filling		Warp Folded		Filling Folded	
	Emery	Alox.	Emery	Alox.	Emery	Alox.	Emery	Alox.
Serge.....	0.89	0.92	0.78	0.88	0.89	0.90	0.98	0.90
Herringbone twill.....	0.93	0.47	0.92	0.76	0.55	0.72	0.83	0.85

^a Spearman's rank correlation coefficient, ρ , is expressed by the following formula:

$$\rho = 1 - \frac{6 \sum d^2}{N(N^2 - 1)}$$

where d = difference in rank between paired items in two series, and N = number of ranks.

^b W, F, WF, FF designate warp, filling, warp folded, and filling folded, respectively.

Ranks were assigned to the number of cycles from the highest to the lowest. A value of one for ρ would indicate perfect association and zero none. The relatively high values of most of the coefficients, as seen in Table III, suggest that although the laboratories might differ among themselves, each, individually, is quite consistent.

To further substantiate the rankings of the laboratories, a check was made for any possible fortuitousness of the results by performing eight one-way analyses of variance of rank for each of the four directions of abrasion (warp, filling, warp folded, and filling folded) for the first rupture and threadbare end points for each of the two abradants. The design of the analyses is illustrated by the following outlines:

WARP ^a Laboratory											FIRST RUPTURE—EMERY ^b Laboratory										
Group	1	2	3	4	5	6	7	8	9	10	Group	1	2	3	4	5	6	7	8	9	10
FR-E...											W....										
FR-A...											F....										
T-E....											WF...										
T-A...											FF...										

^a Repeated for Filling, Warp Folded, and Filling Folded.

^b Repeated for First Rupture—Aloxite, Threadbare—Emery, and Threadbare—Aloxite.

Thus for each of the eight sets there are four rows and ten columns. Following the method suggested by Friedman (3), the statistical test is set up to determine whether the different columns, which show the rankings of each laboratory, came from the same population and therefore would indicate that the ranks would be due to chance and consequently that the laboratories are inconsistent.

The statistic x^2 was computed⁴ which

⁴ The x^2 distribution = Ns^2/σ^2 , where:

	General Case	For Ranked Data
Degrees of freedom for means...	$\frac{N}{2}(p+1)$	$\frac{p-1}{2}(p+1)$
Mean		
Sample variance...	s^2	$\sum_{j=1}^{10} \frac{1}{p} [\bar{r}_j - \frac{1}{2}(p+1)]^2$
Population variance of means...	$\frac{\sigma^2}{N}$	$\frac{p^2-1}{12n}$

Thus, for ranked data

$$x_r^2 = \frac{12n}{p(p+1)} \sum_{j=1}^{10} [\bar{r}_j - \frac{1}{2}(p+1)]^2$$

where:

\bar{r}_j = average of j th column,

n = number of rows = 4, and

p = number of columns or ranks = 10.

For small values of n and large values of p , the significance of x_r^2 is tested by considering

$$\frac{x_r^2 - (p-1)}{\left[\frac{2(n-1)(p-1)}{n} \right]^{\frac{1}{2}}}$$

as a normally distributed variant with zero mean and unit variance.

has the x^2 (chi-square) distribution when the ranking is random. The results of these analyses indicate that the probability that the rankings were due

to chance alone in each of the eight sets for both the serge and the herringbone twill was less than one in a thousand, and illustrate the marked consistency of the ten laboratories in evaluating the abrasion resistance under eight different conditions.

Having determined that the laboratories were consistent as to their relative standings in the number of cycles necessary to reach a given visual end point, exclusive of the first wear end point, under various experimental conditions, the analysis then considered the internal consistency within each laboratory. The assumption was made that there should be a similarity of ratios of the number of cycles to abrade each fabric fillingwise, warpwise folded, and fillingwise folded, respectively, to the warp

were calculated. When these data are plotted as in Fig. 3 the evidence of internal consistency of the laboratories is perhaps more easily observed. For example, all 16 percentages for laboratory F lie between 70 and 79. Similarly, 13 of the 16 percentages for laboratory D lie between 60 and 76. For company J, on the other hand, the values vary from 10 to 81 per cent. A vivid illustration of the differences in visual end points as judged by the various agencies is furnished in Fig. 4.

Conclusions from the First Interlaboratory Test:

Using the Wyzenbeek Precision Wear Test Meter as an interlaboratory test instrument for abrading 8.5-oz. cotton herringbone twill and 10.5-oz. wool serge shows that:

1. There is a high consistency among the laboratories in so far as ranking is concerned.

2. There is a low consistency among the laboratories in so far as actual numerical values are concerned.

3. There is a high association between the first rupture end point and the threadbare end point, indicating the lack of necessity for abrading to the latter stage.

4. Certain laboratories exhibit decidedly higher internal consistency than others.

SECOND INTERLABORATORY TEST

Replies to a questionnaire circulated after the first test showed that the age of the instruments used varied from a few months to 16 yr. and that many machines had not been calibrated since leaving the manufacturer. Therefore, before the second test was begun the cooperating laboratories were requested

TABLE IV.—CONSISTENCY OF LABORATORIES.
HERRINGBONE TWILL FABRIC

Laboratory.....	C	D	E	F	G	H	I	J	K	L
Abradant: Emery.....	G	G	G	G	G	G	G	P	P	P
Aloxite.....	G	G	P	G	P	G	G	P	G	P

SERGE FABRIC

Laboratory.....	C	D	E	F	G	H	I	J	K	L
Abradant: Emery.....	G	G	G	G	G	G	G	G	G	G
Aloxite.....	G	G	G	G	G	G	G	G	G	G

Note.—G = Good consistency. P = Poor consistency.

Parenthetically it may be stated that several laboratories which exhibited poor internal consistency later indicated that operators had been changed during the test or that the decision as to the proper visual end point had been modified.

In a separate attempt to illustrate consistency, the percentages of cycles to reach the first rupture end point to the cycles to reach the threadbare end point

to return their instruments to the maker for overhauling and calibrating. Upon completion of these arrangements the machines presumably were in first-class condition.

The purpose of this second interlaboratory test was to compare the similarity of the machines in regard to the amount of abrasion occurring in a number of fabrics. A second objective was to ascertain the reproducibility and

consistency of the results from each laboratory for the purpose of obtaining an indication of the causes contributing to the variability of the values both within and among the laboratories.

In order to get conclusive results concerning the efficacy of the Wyzenbeek apparatus as an inter-laboratory instrument, the test specimens were pre-cut and the breaking strengths of the abraded specimens were determined on a single tensile tester by a single operator, both being in statistical control. By indicating which specimens were to be abraded on a given arm, the experiment permitted the assignment of a large portion of the total variation to specific causes. Each cooperating member received randomized specimens of five fabrics, two abrasives, and a test directive, which read as follows:

ABRASION TEST METHOD

Scope:

To determine the reproducibility of the characteristics of the Wyzenbeek Precision Wear Test Meter among laboratories in terms of a selected end point of abrasion. For this study, the end point is the percent loss in breaking strength. The abraded specimens will be evaluated at the Philadelphia Quartermaster Depot with a single Scott Vertical Tensile Tester. Statistical control techniques will be utilized.

Specification:

Machine:

Wyzenbeek Precision Wear Test Meter.

Number of arms: 3 or 4.

Rate of oscillation: approximately 90 cycles (double rubs) per minute.

Atmospheric Conditions:

Temperature— 70 ± 2 F.

Relative humidity— 65 ± 2 per cent.

Design of Experiment:

Number of Specimens Abraded

	Aloxite	Emery
Fabric(Cottons)	Arm: 1 2 3 4	Arm: 1 2 3 4
Herringbone twill.....	7 7 7 7	7 7 7 7
Poplin.....	7 7 7 7	7 7 7 7
Sateen.....	7 7 7 7	7 7 7 7
Sateen (filling) ^a	7 7 7 7	7 7 7 7
2/1 Twill.....	7 7 7 7	7 7 7 7

^a Filling flush.

^b The specimens of all fabrics except this one were cut warpwise.

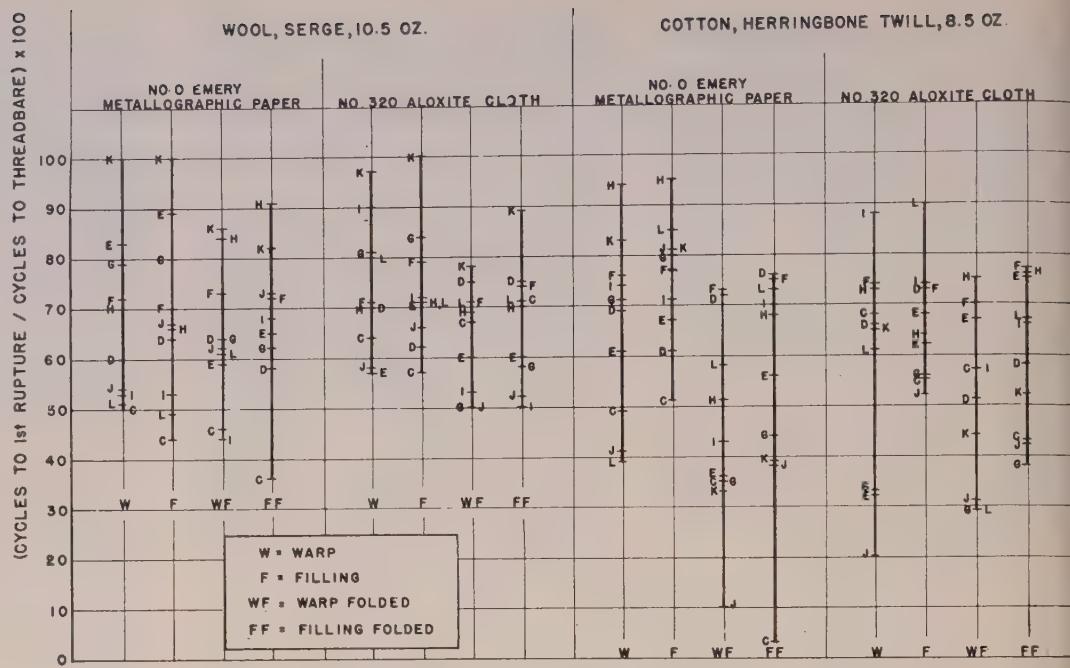


Fig. 3.—Percentages of Cycles to Reach First Rupture End Point to Cycles to Reach Threadbare End Point.



Fig. 4.—Cotton, Herringbone Twill, 8.5 oz.
Numbers denote cycles to threadbare stage.

TABLE V.—AMOUNT OF ABRASION OF 14 INSTRUMENTS ON FOUR FABRICS.
EMERY ABRADANT

Laboratory	Herringbone Twill				Poplin				Sateen				2/1 Twill			
	RBS ^a \bar{X} , lb.	Dev. from \bar{X} , %	B. S. ^b Loss		RBS ^a \bar{X} , lb.	Dev. from \bar{X} , %	B. S. ^b Loss		RBS ^a \bar{X} , lb.	Dev. from \bar{X} , %	B. S. ^b Loss		RBS ^a \bar{X} , lb.	Dev. from \bar{X} , %	B. S. ^b Loss	
			Per cent	Rank			Per cent	Rank			Per cent	Rank			Per cent	Rank
No. 1.....	93	0.3	19	1	96	1.7	29	2	67	1.1	43	3.5	65	5.9	43	3.5
No. 2.....	82	12.1	28	1	85	10.0	37	2	58	12.5	51	4	59	14.6	48	3
No. 3.....	94	0.8	18	1	102	8.0	24	2	65	2.0	45	4	72	4.2	36	3
No. 4.....	97	4.0	15	1	109	15.5	19	2	75	13.1	37	3	70	1.3	38	4
No. 5.....	93	0.3	19	1	85	10.0	37	2	58	12.5	51	4	69	0.1	39	3
No. 6.....	99	6.1	13	1	89	5.7	34	2	64	3.5	46	4	69	0.1	39	3
No. 7.....	94	0.8	18	1	105	11.2	22	2	74	11.6	38	4	74	7.1	35	3
No. 8.....	83	11.0	27	1	81	14.2	40	2	43	35.1	64	4	66	4.5	42	3
No. 9.....	99	6.1	13	1	101	7.0	25	2	82	23.7	31	3	74	7.1	35	4
No. 10.....	87	6.8	24	1	84	11.0	38	2	59	11.0	50	4	61	11.7	46	3
No. 11.....	104	11.5	9	1	114	20.8	15	2	87	31.2	27	4	84	21.6	26	3
No. 12.....	94	0.8	18	1	87	7.8	36	2	63	5.0	47	4	65	5.9	43	3
No. 13.....	90	3.5	21	1	91	3.6	33	2	62	6.5	48	4	68	1.6	40	3
No. 14.....	97	4.0	15	1	93	1.5	31	2	71	7.1	40	4	72	4.2	36	3
Average.....	93.3	4.9	18.3		94.4	9.1	30.0		66.3	12.6	44.1		69.1	6.4	39.0	
Minimum.....	82	0.3	9		81	1.5	15		43	1.1	27		59	0.1	26	
Maximum.....	104	12.1	28		114	20.8	40		87	35.1	51		84	21.6	48	
Range.....	22	11.8	19		33	19.3	25		44	34.0	24		25	21.5	22	

ALOXITE ABRADANT

No. 1.....	60	9.5	48	1	56	26.1	59	2	27	19.6	77	4	36	9.1	68	3
No. 2.....	47	29.1	59	1	32	27.9	76	2	17	49.4	86	4	22	44.4	81	3
No. 3.....	80	20.7	30	1	59	32.9	56	2	38	13.1	68	4	43	8.6	62	3
No. 4.....	72	8.6	37	1	49	10.4	64	2	42	25.0	65	3	35	11.6	69	4
No. 5.....	84	26.7	27	1	43	3.2	68	3	29	13.7	76	4	46	16.2	59	2
No. 6.....	68	2.6	41	1	51	14.9	62	3	33	1.8	72	4	45	13.6	60	2
No. 7.....	64	3.5	44	1	47	5.9	65	3	37	10.1	69	4	44	11.1	61	2
No. 8.....	48	27.6	58	1	34	23.4	75	3	28	16.7	76	4	36	9.1	68	2
No. 9.....	86	29.7	25	1	60	35.1	56	3	57	69.6	52	2	48	21.2	58	4
No. 10.....	60	9.5	48	1	37	16.7	73	3	22	34.5	81	4	38	4.0	66	2
No. 11.....	82	23.7	28	1	72	62.2	47	2	59	75.6	50	3	53	33.8	53	4
No. 12.....	72	8.6	37	1	32	27.9	76	3.5	29	13.7	76	3.5	39	1.5	66	2
No. 13.....	51	23.1	55	1	20	55.0	85	4	22	34.5	81	3	37	6.6	67	3
No. 14.....	54	18.6	53	1	29	34.7	79	4	31	7.7	74	3	32	19.2	72	2
Average.....	66.3	17.3	42.1		44.4	26.9	67.2		33.6	27.5	71.6		39.6	15.0	65.0	
Minimum.....	47	2.6	25		20	3.2	47		17	1.8	50		22	1.5	53	
Maximum.....	86	29.7	59		72	62.2	85		59	75.6	86		53	44.4	81	
Range.....	39	27.1	34		52	59.0	38		42	73.8	36		31	42.9	28	

^a Residual breaking strength (average of 28 values).

^b Breaking strength.

Procedure:

1. For each fabric, abrade seven of the eight sets of four specimens. The extra set has been included in case of error or necessity for recheck.

2. Abrade specimens marked "1" on arm 1, "2" on arm 2, etc. For three-armed models, disregard specimens marked "4."

3. Use a new sheet of abradant for each set of specimens.

4. Specimens are to be inserted into arm clamps so that the side of the fabric marked in red will rest against the abradant.

5. Employ the following test conditions:

(a) 2-lb. load.

(b) 2-lb. tension.

(c) 250 continuous cycles.

6. Identify and keep in chronological order each set of specimens by tagging the strips together and marking Run 1, Run 2, ..., Run 7.

7. Return sets of abraded specimens and unused fabric strips to Philadelphia.

The fabrics were abraded warpwise and broken warpwise except for one of the groups of sateen which was abraded and broken fillingwise. The two groups of sateen, basically the same fabric, were included to determine whether

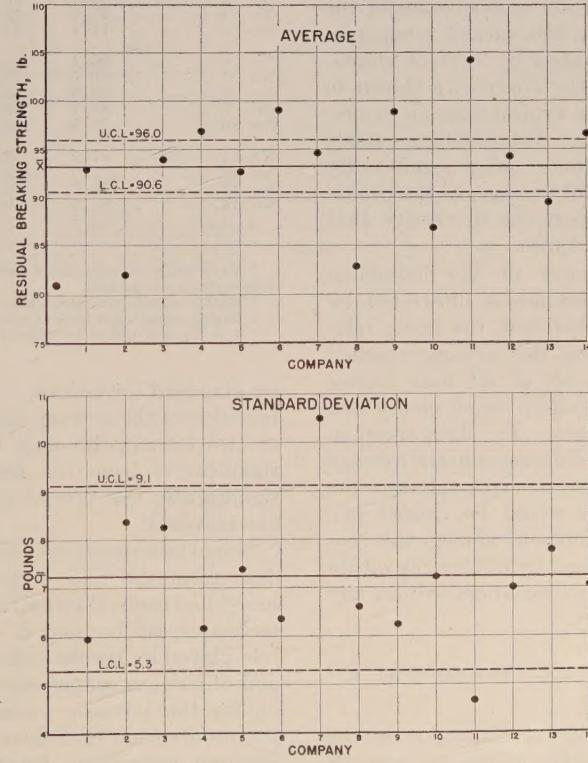


Fig. 5.—Control Charts on the Amount of Abrasion and Variability of Fourteen Wyzenbeek Machines.

TABLE VI.—VARIABILITY OF ABRASION OF 14 INSTRUMENTS ON FOUR FABRICS.

Laboratory	Standard Deviation, σ , lb. ^a							
	Herringbone Twill		Poplin		Sateen		2/1 Twill	
	Emery	Alox.	Emery	Alox.	Emery	Alox.	Emery	Alox.
No. 1.....	6.0	10.2	8.1	8.7	11.5	6.1	10.3	7.9
No. 2.....	8.3	12.9	12.5	9.9	8.2	5.9	7.9	7.9
No. 3.....	8.3	10.6	8.6	7.4	8.9	6.0	6.7	6.3
No. 4.....	6.2	9.4	6.5	11.3	8.9	9.6	7.4	5.9
No. 5.....	7.4	6.5	10.8	9.2	10.0	5.7	10.3	8.0
No. 6.....	6.3	11.6	10.8	13.3	9.4	11.0	9.7	8.8
No. 7.....	10.5	11.1	7.8	11.3	10.1	7.8	8.0	7.5
No. 8.....	6.6	7.2	11.0	8.6	6.7	5.5	9.7	7.5
No. 9.....	6.2	6.9	13.1	13.5	8.9	13.1	5.8	9.9
No. 10.....	7.2	14.8	9.1	13.9	8.7	9.8	10.9	12.0
$\bar{\sigma}$, lb. ^b	7.2	10.4	10.3	11.3	9.5	9.0	8.7	9.1
\bar{X} , lb. ^c	93.3	66.3	94.4	44.4	66.3	33.6	69.1	39.6
\bar{X} Chart:								
UCL, lb. ^d	96.0	70.2	98.3	48.7	69.9	37.0	72.4	43.0
LCL, lb. ^d	90.6	62.4	90.5	40.1	62.7	30.2	65.8	36.2
σ Chart:								
UCL, lb. ^e	9.1	13.2	13.1	14.3	12.0	11.4	11.0	11.5
LCL, lb. ^e	5.3	7.6	7.5	8.3	7.0	6.6	6.4	6.7

$$a \sigma = \sqrt{\frac{\sum(x - \bar{x})^2}{N - 1}}$$

b $\bar{\sigma}$ = Square root of average of 14 individual σ^2 's.

c Values from Table V.

d For \bar{X} control chart: Upper control limit, UCL = $\bar{X} + 2\bar{\sigma}\sqrt{28}$. Lower control limit, LCL = $\bar{X} - 2\bar{\sigma}\sqrt{28}$.

e For σ control chart: Upper control limit, UCL = $\bar{\sigma} + 2\bar{\sigma}\sqrt{56}$. Lower control limit, LCL = $\bar{\sigma} - 2\bar{\sigma}\sqrt{56}$.

TABLE VII.—OVER-ALL COMPARISON OF AMOUNT OF ABRASION AND REPRODUCIBILITY OF 14 WYZENBEK TESTERS.

Laboratory	Residual Breaking Strength of 112 Specimens, lb.						Reproducibility, σ_E^2/A^2	Consistency, χ^2		
	Emery Abradant			Aloxite Abradant						
	\bar{X}	σ_E^2	σ_E^*	\bar{X}	σ_A^2	σ_A^*				
No. 1.....	80.1	77.10	8.8	44.7	53.53	7.3	1.44	3.1		
No. 2.....	70.9	66.35	8.2	29.4	62.18	7.9	1.07	5.0		
No. 3.....	83.3	65.52	8.1	54.7	60.39	7.8	1.08	4.0		
No. 4.....	87.6	53.10	7.3	49.4	45.62	6.8	1.16	5.2		
No. 5.....	76.1	91.48	9.6	50.5	41.78	6.5	2.19 ^a	7.8 ^b		
No. 6.....	80.4	51.60	7.2	49.0	52.73	7.3	0.98	1.4		
No. 7.....	86.7	77.80	8.8	48.0	64.81	8.1	1.10	3.7		
No. 8.....	68.0	46.53	6.8	36.3	48.01	6.9	0.97	2.1		
No. 9.....	89.1	69.40	8.3	62.8	88.23	9.4	0.79	3.6		
No. 10.....	72.8	62.83	7.9	38.9	84.92	9.2	0.74	5.2		
No. 11.....	97.2	68.13	8.3	66.5	85.39	9.2	0.80	1.4		
No. 12.....	77.0	102.85	10.1	42.8	57.04	7.6	1.80 ^a	9.8 ^b		
No. 13.....	77.6	66.28	8.1	32.4	83.23	9.1	0.80	12.2 ^b		
No. 14.....	83.2	60.69	7.8	36.2	72.05	8.5	0.84	4.5		
Average.....	80.7		8.3 ^c	45.8		8.0 ^c				

* Variability of apparatus and technique, after elimination of variability caused by material and differences among arms.

^a Highly significant, indicating lack of reproducibility of results due to apparatus or technique.

^b Highly significant lack of consistency.

^c $\bar{\sigma}$ = Square root of average of 14 individual σ^2 's.

by standard deviations. Although the precision of the average values from one or two laboratories may have differed significantly from the rest, none was significantly less precise for more than one material.

Since this experiment yielded sufficient data from the four materials for the individual arms, the analysis of variance technique can be used to eliminate the role played by the heterogeneity of arms and differences among materials and so obtain the intrinsic variability, σ^2 , of the results from each laboratory. This intrinsic variability, listed by laboratories in Table VII, includes differences within the fabrics (known to be rela-

tively minor) and the variability of the machines, exclusive of the effects of the arms. The intrinsic variability is shown to be the basic variability of the machines by the fact that approximately the same average value is obtained for all laboratories irrespective of abradant used. Therefore, it would be expected that within each laboratory, the ratio of the intrinsic variability obtained with emery abradant to that obtained with Aloxite abradant equals approximately unity. If this ratio is significantly greater than one for a laboratory, the reproducibility and consistency of its instrument would be seriously questioned. Consequently, the reproduc-

warpwise abrasion affects the breaking strength of the protected yarns. It was noted that regardless of direction of abrasion of filling-flush sateen, the filling yarns bore the brunt of the degradation. As the loss in warp breaking strength after 250 cycles was negligible, data for the warpwise-cut sateen were not included in the following analysis.

Comparison of Amount of Abrasion:

Considering one fabric abraded by one medium on a four-arm apparatus (the model used by all but one laboratory), it is seen that this experiment yielded 28 individual values for the residual breaking strength per laboratory. Table V compares the average amount of abrasion of the 14 instruments studied for the four fabrics using emery and Aloxite abrasants. The values show a dissimilarity in the performance of the various machines, for the average range of the percentage loss in strength after abrasion is approximately 23 per cent when emery is used and 33 per cent when Aloxite is the abradant. Despite these wide ranges with emery abrasive there are but three different rankings of the four fabrics. Eleven of the 14 laboratories ranked the materials identically, one rated the third and fourth fabrics equally, while the remaining two reversed the third and fourth fabrics. Use of the Aloxite resulted in six different rankings, showing the greater consistency of the emery.

The significance of the differences in the amount of abrasion of each of the four fabrics by the various companies may be illustrated by control charts. The data for the charts are shown in Table VI and a typical example is presented as Fig. 5. Values falling outside the control limits differ significantly from the over-all average, as the probability is less than one in twenty that they do so by chance.

The consistency of the individual Wyzenbeek machines is illustrated by Fig. 5, which indicates the linear relationships among the average residual breaking strength of all four fabrics from each laboratory using emery and Aloxite abrasants. The data show, in short, that the differences in the average residual breaking strength values of the 14 laboratories would be caused primarily by differences among the machines rather than by differences within the fabrics or to variations within any given apparatus.

Reproducibility and Consistency of Results:

The variability or dispersion of the breaking strength values of the 28 abraded specimens of each fabric for each laboratory is shown in Table VI

TABLE VIII - NON-HOMOGENEITY OF ARMS BASED UPON RESIDUAL BREAKING STRENGTH

BS	ABRADANT	HBT				POPLIN				SATEEN				2/1 TWILL				AVERAGE OF ALL FABRICS				RANKING OF ARMS	
		ARM				ARM				ARM				ARM				ARM					
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4		
1	E	97.3	93.0	89.7	91.7	99.6	97.0	89.9	97.6	74.4	67.7	62.3	63.1	70.6	63.3	58.9	65.4	85.5	80.2	75.2	79.5	3-42-1	
	A	62.7	63.7	50.9	64.1	57.4	53.3	48.7	62.6	31.9	30.1	24.0	23.1	39.7	34.9	29.4	38.4	47.9	45.5	38.3	47.1	3-24-1	
2	E	81.7	82.9	75.1	88.6	92.6	83.1	71.6	91.3	57.9	58.4	55.6	61.7	57.9	60.3	52.3	63.7	72.5	71.2	63.6	76.3	3-214	
	A	41.4	53.3	38.6	53.4	21.7	29.9	32.4	43.7	13.0	18.9	16.1	19.7	20.0	24.4	15.7	28.1	24.0	31.6	25.7	36.3	13-24	
3	E	92.4	92.0	99.1	92.9	96.3	106.0	105.7	99.6	63.1	67.9	65.1	64.0	72.7	69.7	71.9	74.3	81.1	83.9	85.5	82.7	I-23	
	A	75.4	83.3	81.6	77.0	60.9	59.0	59.1	58.0	37.3	40.1	33.9	38.7	40.3	44.7	47.0	38.4	53.5	56.8	55.4	53.0	4132	
4	E	98.4	97.6	95.3	95.7	107.9	113.0	106.0	100.0	72.1	81.0	74.7	72.6	73.6	68.4	67.9	69.4	88.0	90.0	86.0	86.4	341-2	
	A	74.1	74.7	59.4	77.7	44.9	61.3	36.9	53.4	46.9	47.0	31.9	42.0	36.3	34.0	32.6	38.0	50.5	54.2	40.2	52.8	3-142	
5	E	96.3	89.1	94.6	91.0	83.4	79.4	90.1	87.4	53.4	60.0	58.3	59.4	63.9	64.9	72.4	73.6	74.2	73.4	78.9	77.9	214-3	
	A	83.3	82.1	85.3	86.7	36.0	37.3	46.0	51.3	25.1	24.9	33.6	30.7	43.7	43.0	53.3	45.4	47.0	46.8	54.5	53.5	214-3	
6	E	104.9	96.6	99.1	95.3	98.6	92.4	87.4	79.0	69.7	59.3	70.3	57.1	78.0	73.3	65.9	59.4	87.8	80.4	80.7	72.7	4-23-1	
	A	78.4	72.0	67.7	54.3	60.6	59.6	45.9	36.0	43.7	37.1	30.3	19.0	55.3	46.3	38.7	39.3	59.5	53.7	45.6	37.1	4-32-1	
7	E	91.9	92.0	96.4	97.4	108.3	107.0	101.9	101.1	79.7	71.7	76.4	69.3	81.0	68.9	68.9	75.3	90.2	84.9	85.9	85.8	243-1	
	A	71.1	58.4	60.1	66.4	41.0	43.0	43.0	59.6	42.0	30.9	33.4	42.0	42.9	42.9	38.6	52.1	49.2	43.8	43.8	55.0	231-4	
8	E	85.1	80.9	84.0	81.3	72.3	77.7	97.7	75.0	39.9	40.9	50.1	41.1	67.7	69.0	66.1	59.7	66.2	67.1	74.5	64.3	412-3	
	A	51.7	47.4	51.6	41.7	35.4	36.3	31.6	30.6	28.6	23.1	32.3	26.9	35.7	36.0	39.9	32.3	37.9	35.7	38.8	32.9	4-213	
9	E	95.3	100.1	100.7	99.6	102.7	104.7	106.0	89.7	76.4	87.6	84.6	80.7	71.4	74.6	72.4	78.7	86.5	91.7	90.9	87.2	I-43-2	
	A	83.4	86.6	84.3	88.1	44.9	62.3	72.0	61.9	43.6	67.0	61.1	55.9	50.6	50.4	47.1	45.4	55.6	66.6	66.1	62.8	I-43-2	
10	E	80.4	92.7	87.3	87.1	74.9	92.9	85.4	82.7	56.9	68.4	56.3	53.7	56.9	66.1	62.1	60.3	67.2	80.0	72.8	71.0	I-43-2	
	A	45.6	79.7	58.7	54.0	28.0	53.4	28.7	35.7	20.1	29.9	17.3	19.4	28.7	43.4	45.9	33.1	30.6	51.6	37.6	35.6	I-43-2	
11	E	104.6	104.3	104.7	103.9	112.3	116.6	116.1	109.9	84.6	81.0	95.1	86.6	82.3	83.7	89.6	80.4	95.9	96.4	101.4	95.2	412-3	
	A	83.6	85.4	84.1	75.3	71.7	77.7	74.9	63.3	58.7	54.7	59.4	62.6	55.9	60.3	47.9	48.7	67.5	69.5	66.6	62.3	4132	
12	E	96.9	88.4	98.1	93.1	84.7	84.0	86.9	91.7	61.9	58.4	67.1	61.4	65.7	57.4	68.6	67.7	77.3	72.1	80.2	78.5	2-143	
	A	75.4	67.3	80.0	65.6	30.7	28.1	33.7	33.9	33.4	23.3	25.3	31.7	36.6	35.4	43.4	40.9	44.0	38.5	45.6	43.0	2-143	
13*	E	84.1	90.1	94.7	----	95.1	80.4	95.9	----	58.0	64.4	64.6	----	67.7	67.4	69.1	----	76.2	75.6	81.1	----	21-3	
	A	44.1	49.4	60.4	----	6.7	12.7	41.3	----	14.9	21.7	28.3	----	32.1	26.6	51.0	----	24.5	27.6	45.2	----	12-3	
14	E	94.3	95.4	98.4	98.7	91.6	85.0	91.6	104.4	69.6	65.3	74.6	75.9	70.1	73.9	67.4	74.4	81.4	79.9	83.0	88.4	321-4	
	A	42.3	45.6	64.6	61.7	26.3	21.3	30.3	37.7	30.4	22.1	30.7	38.6	30.0	23.3	35.1	39.1	32.2	28.1	40.2	44.3	213-4	

*THREE-ARM MODEL

ility of the results from laboratories 5 and 12 would be doubtful, their values for the ratio being 2.19 and 1.80, respectively, instead of being approximately 1.0.

The internal consistency can be checked by using the chi-square technique, which evaluates the discrepancy between the values theoretically obtained on the basis of the assumption and the actual values. In this case, the chi-square analysis was used to ascertain significance of the difference between the actual and the theoretical ratios of the average residual breaking strengths of the four fabrics using each abrasive. The theoretical ratios were computed on the assumption that the residual breaking strength of each of the materials abraded in a laboratory should form a constant ratio regardless of the abradant in order that the results of a laboratory be considered consistent.

The lack of reproducibility of laboratories 5 and 12 conclusion is substantiated by their lack of consistency, for their values of χ^2 are 7.8 and 9.8, respectively. The high value of χ^2 for laboratory No. 13 is a result of a sharp reversal of the data when emery and Aloxite were used.

Contributory Causes of Variability:

Hitherto the discussion of results has not considered possible causes of the heterogeneity of the arms, but a study of the Wyzenbeek tester would not be com-

plete without an analysis of this factor. The data of Table VIII, which are the average breaking strengths of the specimens inserted into each arm of each instrument, show the arms which yield results significantly different from their mates. As the rubber pads used in the Wyzenbeek apparatus may differ considerably in physical characteristics, and thus in their abrading efficiency, employment of homogeneous pads would result in greater reliability. Further, by bringing the differing arm into line with the others, much closer control limits would be obtained. In a separate experiment, interchanging the pads among

the arms of a single instrument resulted in a reranking of the arms. Thus, differences in the rubber abrading pads are an important factor contributing to the differences among instruments, but it is not the only machine factor.

This study indicates that the use of No. 0 emery abradant yields results having 50 per cent less variability than does the use of No. 320 Aloxite abrasive. As previously mentioned, an excellent consistency exists in the individual evaluation of all the fabrics tested by each laboratory when emery is employed. The consistency is much less apparent when Aloxite is used.

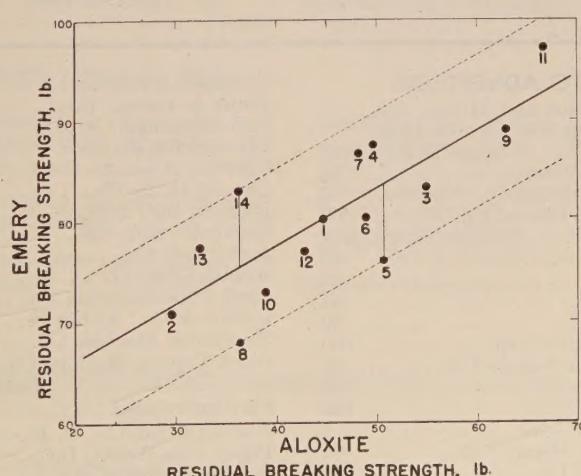


Fig. 6.—Consistency of Individual Wyzenbeek Machines.

A comparison of the two types of end points is made possible by the two interlaboratory tests since herringbone twill fabric was used in each. In the first test a subjective end point was studied, namely, the number of cycles of abrasion required to produce a described change in appearance. In the second test the

2. It cannot be employed in establishing a general standard.

3. Increase in precision may be achieved by

- (a) using an objective end point whenever feasible;
- (b) employing a mild uniform abrading agent;

TABLE IX.—VARIABILITIES OF THE TWO TYPES OF END POINTS USING EMERY ABRADANT AND HERRINGBONE TWILL FABRIC.

Per cent Deviation from Mean:	Objective End Point, Loss in Breaking Strength, per cent	Subjective End Point			
		1st Rupture		Threadbare	
		W	F	W	F
Average.....	21.7	68	64	56	59
Range.....	50.6	261	295	175	210
Coefficient of Variation, V.....	30.2	104	109	78	87
Ratio of $V_{\text{sub}}/V_{\text{obj}}$.....	....	3.5	3.6	2.6	2.9

end point was objective, for the loss in breaking strength after an arbitrary number of cycles of abrasion was noted. Comparative values of the coefficients of variation among laboratories for the two end points are shown in Table IX.

From this table, it will be seen that the coefficients of the subjective end points are approximately thrice that of the objective end point.

CONCLUSIONS

On the basis of the results reported in this paper, the following conclusions may be stated:

1. In its present state, the Wyzenbeek Precision Wear Test Meter can be used:

- (a) In evaluating differences among materials by a given laboratory;
- (b) For interlaboratory checks by cooperating laboratories if their instruments are predetermined to be sufficiently similar in abrasive action and reproducibility.

- (c) utilizing control chart techniques to ensure consistency among arms and tests.

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